HOUSE . . . . No. 1672

The Commonwealth of Massachusetts.

IN BOARD OF GAS AND ELECTRIC LIGHT COMMISSIONERS,
BOSTON, Jan. 15, 1912.

To the Honorable Senate and House of Representatives in General Court assembled.

At the legislative session of 1910 the following order was adopted and transmitted to this Board: —

Ordered, That the Board of Gas and Electric Light Commissioners shall investigate the operation of demand indicators, so called, used by electric light companies, and shall determine whether or not it is expedient to regulate or prohibit the use of such meters. Said Board shall report on this subject not later than January 15.

Pursuant to this order the Board has made the investigation directed and, in connection therewith, on the sixth and twenty-seventh days of October, 1911, gave public hearings to all persons interested. Due notice of these hearings was given by publication in the Boston press and also to the persons who introduced the legislation which gave rise to this order, to the members of the Committee on Mercantile Affairs of the Legislature of 1911, who reported the order, to the mayor or selectmen of all municipalities in which electric light companies are engaged in business, to certain business and civic associations who have been accustomed to interest themselves in such questions and to the electric light companies.

In addition to the information developed at these hearings, the Board has directed inquiries to all the companies and municipalities engaged in the sale of electricity, relative to the extent and pur-

pose of the use of demand indicators and the means employed to ensure their accuracy. It has also employed Prof. F. A. Laws of the Massachusetts Institute of Technology to make an examination into and report upon the mechanical and technical features of these appliances and to conduct a series of tests of Wright demand indicators, which are largely used by the Edison Electric Illuminating Company of Boston.

His report in full, except the appendix thereto, which may be consulted at this office, constitutes Appendix A of this report.

As a result of its investigation, the Board respectfully submits its report as follows: —

Use of Demand Indicators.

Upon inquiry of the companies and municipalities making returns to the Board, it appeared that 69 companies and 23 municipalities had no demand indicators in use on June 30, 1911. Twelve companies and 4 municipalities had 11,613 demand indicators in use on that date, but of these 10,745 belonged to the Edison Electric Illuminating Company of Boston, 303 to the Haverhill Electric Company, 291 to the Malden Electric Company, 86 to the Norwood Municipal Plant, 71 to the Salem Electric Lighting Company, 53 to the Lowell Electric Light Corporation, 21 to the Fitchburg Gas and Electric Company, 17 to the Worcester Electric Light Company and the remaining 26 to the other 5 companies and 3 municipalities. Of the demand indicators in use, 11,447 were of the type known as "Wright Maximum Demand Indicators," 95 were of the type known as "Ingalls Relay Demand Indicators," and 71 of the type known as "General Electric Maximum Watt Demand Indicators, Type W." The Edison Company of Boston owned 10,745 of the Wright Demand Indicators and all of the Ingalls Relay Indicators.

One or two companies have recently installed an appliance known as an "excess indicator," which causes a noticeable interruption of service if more than a certain prearranged amount of electricity is required by a customer at any one time. One company had 250 of these appliances in use on June 30, 1911. Such an "excess indicator," however, is not a "demand indicator," as this term is ordinarily used. It does not measure anything or determine any factor used in fixing the charge made for electricity

supplied to the customer, but serves to limit merely his use of the supply. For these reasons the Board has not included such "excess indicators" in its investigation.

Demand Indicators and their Operation.

In the report made to the Board by Professor Laws, a copy of which is hereto annexed, entitled Appendix A, descriptions are given of the three types of demand indicators in use as above described. These descriptions are accompanied by sketches of the devices and explanations of their operation when in service, and are as concise as is consistent with clearness. It seems unnecessary to repeat them here, but to refer those desiring to know the technical details of their mechanism and operation to his report.

The Wright demand indicator, as will be seen by reference to his report, is in appearance a metal box with an index tube and scale exposed to view and its working parts enclosed. It is designed to register automatically by the rise of the liquid in the exposed index tube when a sufficient time to ensure its complete operation is allowed the volume of electric current delivered. In a two-wire service one such indicator is installed on the customer's side of the recording watt hour meter, and in a three-wire service two indicators are so installed, one on each side of the neutral wire. Once installed it will register the greatest volume of current passing through it at any one time without, however, leaving any trace as to the time when this occurs. The registration is in amperes, the technical unit of current strength or rate of delivery. In order to ascertain the power required by the customer at the time of the highest registration of the instrument, the amperage thus registered must in direct current use be multiplied by the voltage at which electricity is delivered to that service. The result in watts is often spoken of as the customer's demand. In practice, immediately after the reading of this instrument is made and noted by the reader, it is reset by him. No trace of its indication remains and no opportunity exists for the subsequent verification of the same. This type of indicator costs less than other types, is inexpensive to operate and hence its more extensive use.

It is intended that approximately 90 per cent. of the registration of the volume of current introduced into the indicator shall be accomplished in four minutes, and the entire registration in about

forty minutes. A fair approximation of the final registration, say 85 per cent., occurs more promptly when the indicator is worked at about its full capacity than when it is lightly loaded. Each indicator has its characteristic rate of response to the current. Owing to differences in the tubes it is impracticable to use any printed standard scales for the different sizes of indicators. Each must be graduated by experiment to fit the particular tube to which it is applied.

In the case of the Edison Company of Boston, demands on direct current services and on alternating current services where the load is non-inductive, as for illustration without alternating current motors, are determined by the Wright demand indicator, except in cases where electricity is sold under schedules D and D–1 [1] of the rates of that company now in force.

The Ingalls relay demand indicator is an auxiliary to the watt hour recording meter which registers the amount of electrical energy actually delivered to a customer. Such a recording watt hour meter is essentially a miniature motor driven by the current passing through it. In the Ingalls demand indicator the disc driven by this miniature motor in turn drives another wheel at a slower speed, and the revolutions of this wheel are recorded on a tape drawn at an even speed by clockwork. By this mechanism a continuous record is made by which the customer's demand can be computed and determined for any hour of the period for which the indicator is set. This instrument is far more expensive to purchase and maintain than the Wright demand indicator, and is used by the Edison Company of Boston alone and only in connection with customers purchasing electricity under what is known as the "permanent electric rate" schedule. (See Appendix B, schedules D and D–1.)

The General Electric Type W watt demand indicator is in outward appearance a watt hour meter, but, in place of the dials and hands by which the number of watt hours is recorded, there is but one dial with two hands and a scale registering in kilowatts from zero up, according to the capacity of the indicator. It is designed for use on alternating current circuits and for polyphase work only. In addition to the mechanism ordinarily found in a watt meter of the induction type, a second disc mounted on the same spindle rotates between two sets of magnets so arranged as to

[1] See Appendix B.

retard the speed at which the spindle may rotate in response to variations of the load. By a system of gearing the first hand is driven over the dial according to the amount of electrical power delivered, and pushes ahead of it a second hand, which is provided with a ratchet that holds it at the highest point to which it is pushed. At every diminution of the load the first hand falls back towards zero. This instrument records the greatest demand in kilowatts made by the customer at one time, but gives no indication of the time when it occurs; it is intended that the magnets be so set that 90 per cent. of the registration is attained in five consecutive minutes. The original cost and expense of maintenance of this type is much greater than that of the Wright demand indicator already described.

Mechanical Accuracy in Actual Use.

Of the 16 companies and municipalities using demand indicators, 10 reported that they tested the appliances before installation and 6, that they did not. Eight reported that no tests of the appliances were made after they were installed, 3 made occasional tests, 3 tested the appliances whenever a customer demanded such test and 2 made periodic tests. Of the 2 making periodic tests, one had but two demand indicators in use and these were tested once a year. The other, the Edison Company of Boston, examines and tests the indicators before installation. After installation this company has a system of routine inspection by which one-quarter of the number in use are returned to the company's laboratory every year for verification and such correction and repairs as may be found necessary. During the year ending June 30, 1911, this company reports that 2,830 indicators were removed from the customers' premises in this regular routine and were tested. In addition all new indicators purchased and all indicators removed from customers' premises for reasons other than in the regular routine were tested when brought in and the total number of all tests of such indicators during that year was 4,184.

As already stated, Professor Laws made a series of tests of the Wright maximum demand indicators in use by the Edison Company of Boston in order to ascertain their accuracy under ordinary service conditions. Eighty-one indicators of sizes varying from 5 to 300 amperes were selected by him at random, removed

from the premises where installed in his presence or in the presence of his assistant taken to the Standardizing Laboratory of the Massachusetts Institute of Technology and there tested.

His report of these tests is as follows: —

At the laboratory the indicators of a given size were set up and connected in series; currents, either direct or alternating, as the case required, and of the proper magnitude, were sent through them and maintained constant until the readings assumed their ultimate values. The currents were measured by the use of standards certified by the United States National Bureau of Standards at Washington, D. C.

The points selected for calibration were: first, 20 per cent. and 90 per cent. of the full scale reading, the former because it is usually the first mark on the scale, the latter because it is desirable to be able to state the inaccuracy at the upper end of the scale if the indicator should register too much; second, two intermediate points at about 43 per cent. and 66 per cent. were taken, thus dividing the interval between 20 per cent. and 90 per cent. about equally. Tests were made at these four points and then, in order to obtain a check measurement, the whole series was repeated. All tests were made at a room temperature of 68 degrees F., unless otherwise specified.

As the 20 per cent. loadmark is the first one on the scale, no numerical reading is possible unless the indicator is correct or reads too much; so in the first table following it is simply noted whether the reading is too large, correct or too small. The average registration of those indicators which register too much at this point is 113.5 per cent. If those registering correctly be included, the average is 108.7 per cent. The readings at the lower end of the scale are considerably influenced by temperature: for instance, four indicators of 35 amperes capacity were set at 68 degrees F., and then the temperature raised to 104 degrees F., and kept there for four hours, no current being sent through the indicators; the average rise of the liquid in the indicator tubes was .52 inch, which roughly corresponds to a change of reading of 5 amperes at this point. These extremely low readings are not, however, of as great importance as those at the upper end of the scale. For example, it happens that the average percentage reading of the indicators when removed for test was approximately 60 per cent., with an occasional value falling as low as 30 per cent. The effect of temperature becomes smaller as the readings increase.

The following tables show the results of the tests: —

At 20 Per Cent. Load.

Rating of Indicators (Amperes).	Number of Indicators which register too —		Number which register correctly.
	Much.	Little.	
5,	6	2	0
10,	3	3	4
15,	5	3	2
25,	5	4	1
35,	1	3	0
50,	7	2	1
75,	3	4	3
100,	3	1	1
150,	3	0	4
200,	0	2[1]	4[1]
300,	0	1	0
Totals,	36	25	20

[1] At 25 per cent. load being first mark on scale of this indicator.

44.5 per cent. of the indicators register too much. The average excess registration is 13.5 per cent.

30.9 per cent. of the indicators register too little.

24.7 per cent. of the indicators register correctly.

Average excess registration of indicators which register correctly and too much, 8.7 per cent.

At 43 Per Cent. Load.

Rating of Indicators (Amperes).	Number of Indicators registering —						
	110 Per Cent. and More.	109.9–105.1 Per Cent. inclusive.	105–102 Per Cent. inclusive.	101.9–98.1 Per Cent. inclusive.	98–95 Per Cent. inclusive.	94.9–90.1 Per Cent. inclusive.	90 Per Cent. and Less.
5, . . .	0	0	2	4	2	0	0
10, . . .	0	2	2	4	0	1	1
15, . . .	0	0	3	3	4	0	0
25, . . .	0	0	2	6	1	1	0
35, . . .	1	0	2	0	0	1	0
50, . . .	3	3	2	1	0	1	0
75, . . .	1	0	1	4	4	0	0
100, . . .	0	1	2	2	0	0	0
150, . . .	1	3	0	2	0	1	0
200, . . .	0	0	0	5	0	1	0
300, . . .	0	0	0	0	0	0	1
Totals, .	6	9	16	31	11	6	2

71.6 per cent. of the indicators register between 95 per cent. and 105 per cent.
18.5 per cent. of the indicators register more than 105 per cent.
9.9 per cent. of the indicators register less than 95 per cent.

At 66 Per Cent. Load.

Rating of Indicators (Amperes).	Number of Indicators registering —						
	110 Per Cent. and More.	109.9–105.1 Per Cent. inclusive.	105–102 Per Cent. inclusive.	101.9–98.1 Per Cent. inclusive.	98–95 Per Cent. inclusive.	94.9–90.1 Per Cent. inclusive.	90 Per Cent. and Less.
5, . . .	0	0	1	2	4	1	0
10, . . .	0	1	3	4	1	1	0
15, . . .	0	0	2	2	6	0	0
25, . . .	0	0	1	7	1	1	0
35, . . .	1	0	1	1	1	0	0
50, . . .	2	1	4	3	0	0	0
75, . . .	1	0	4	3	2	0	0
100, . . .	0	1	2	2	0	0	0
150, . . .	1	1	2	2	1	0	0
200, . . .	0	0	2	4	0	0	0
300, . . .	0	0	0	0	0	1	0
Totals, .	5	4	22	30	16	4	0

84.0 per cent. of the indicators register between 95 per cent. and 105 per cent.
11.1 per cent. of the indicators register more than 105 per cent.
5.0 per cent. of the indicators register less than 95 per cent.

At 90 Per Cent. Load.

Rating of Indicators (Amperes).	Number of Indicators registering —						
	110 Per Cent. and More.	109.9–105.1 Per Cent. inclusive.	105–102 Per Cent. inclusive.	101.9–98.1 Per Cent. inclusive.	98–95 Per Cent. inclusive.	94.9–90.1 Per Cent. inclusive.	90 Per Cent. and Less.
5, . . .	0	0	1	5	1	1	0
10, . . .	1	0	1	5	2	1	0
15, . . .	0	0	1	7	2	0	0
25, . . .	0	0	1	6	2	1	0
35, . . .	0	2	0	2	0	0	0
50, . . .	0	3	4	2	1	0	0
75, . . .	1	0	1	6	2	0	0
100, . . .	1	1	0	3	0	0	0
150, . . .	2	0	3	0	2	0	0
200, . . .	0	0	3	3	0	0	0
300, . . .	0	0	0	0	0	1	0
Totals, .	5	6	15	39	12	4	0

81.5 per cent. of the indicators register between 95 per cent. and 105 per cent.
13.6 per cent. of the indicators register more than 105 per cent.
5.0 per cent. of the indicators register less than 95 per cent.

Disregarding the readings obtained at 20 per cent. load for the reasons suggested by Professor Laws, and applying the same rule as provided by law for electric meters, namely, that the instrument be deemed correct if it does not vary more than 5 per cent. from the standard, it appears that of the 81 indicators tested at 43 per cent. load, 58 were correct, 15 registered too much and 8 too little, and at 90 per cent. load, 66 were correct, 11 registered too much and 4 too little.

Purpose for which used.

In every instance where demand indicators are employed they are used to determine the greatest demand a customer makes during a given period upon the capacity of the generating plant and distributing system by which he is served. In several cases this demand is ascertained solely for the private information of the management of the company as an aid to determine the size of transformers, meters or conductors. In others it is used as a check upon a demand determined or estimated in some other way. In the majority of instances the maximum demand of the

customer ascertained by these indicators is one factor, and often an extremely important factor, to the customer in the charge made him for his supply of electricity.

Two methods of utilizing the customer's maximum demand are employed in making their charges by companies and municipalities using demand indicators. Some make a definite fixed charge per kilowatt of maximum demand and an additional charge per kilowatt hour for electricity consumed. Others charge the equivalent of a certain number of hours' use of the demand per month at one price and all in excess thereof at a lower price or prices.

The Edison Company of Boston employs both of these methods. In its so-called "yearly lighting rates," and "permanent electric rates," a fixed yearly price payable in equal monthly instalments is charged for each kilowatt of maximum demand, and in addition a price is charged for each kilowatt hour of electricity consumed. In its "power rates" all electricity furnished up to twenty-three hours' use per month of the customer's maximum demand is charged at 12 cents per kilowatt hour, and lower prices and discounts are made for all electricity consumed per month in excess thereof. The demand in the "yearly lighting rates" for each year, beginning the first of February, is the highest reading of the demand indicators during the preceding three months, and in the "power rates," the average of such readings during the preceding four months. The demand in the "permanent electric rates" is fixed in the first instance by agreement with the customer, but must be at least 50 kilowatts; a continuous record of the demand is recorded by the Ingalls indicator, already described, and the charge made accordingly.

Existing Provisions of Law.

In 1901 the Legislature enacted chapter 497, entitled "An Act to provide for the Inspection of Electric Meters." The provisions of this chapter are now sections 36 (amended by chapter 348 of the Acts of 1911), 37 and 38 of chapter 121 of the Revised Laws. These sections read as follows: —

Section 36. A customer of an electric lighting company or such company may apply to the board of gas and electric light commissioners for an examination and test of any meter in use upon a customer's prem-

ises. The board shall forthwith cause to be made by a competent and disinterested person such examination and test of said meter as in the judgment of the board is practicable and reasonable, and shall furnish to the company and to the customer a certificate of the result and expense thereof. If upon such examination it appears that the meter does not register correctly, the board may order the company to correct or remove such meter and to substitute a correct meter therefor. All fees for examinations and tests shall in the first instance be paid by the person or company making application therefor; but if the examination or test is made at the request of a customer and the meter is found to be incorrect because too fast, the company shall pay such fees to the board, to be repaid by it to the applicant. A meter shall be deemed correct for the purposes of this section if it appears from such examination or test that it does not vary more than five per cent. from the standard approved by the board.

Section 37. The person designated to make such inspection may at any reasonable time enter upon any premises where the meter to be inspected is placed, for the purpose of making the inspection. He shall receive such compensation for his services as the board may determine, together with his necessary travelling and other expenses, which shall be audited by the board and paid from the treasury of the commonwealth; but the total amount of compensation and expenses shall not exceed three thousand dollars in any year; and if the total amount of such compensation and expenses shall in any year exceed the amount of the fees received for such examinations and tests, the excess shall be assessed and recovered from the electric light companies in the manner now provided for the assessment and recovery of the other expenses of the board. All money received for fees for such examinations and tests shall be paid into the treasury of the commonwealth by the board quarterly on the first Mondays of January, April, July and October of each year.[1] The board may establish such rules and regulations, fix such standards, prescribe such fees and employ such means and methods in, and in connection with, such examinations and tests of electric meters as in the judgment of the board shall be most practicable, expedient and economical. The board may purchase such materials, apparatus and standard measuring instruments for such examinations and tests as it may deem necessary.

Section 38. In the two preceding sections the word "company" or "companies" shall include every person, partnership, association, corporation and municipality engaged in the sale of incandescent electric light or electricity for incandescent lighting.

In administering this law the Board has always construed it as applying to meters measuring the electrical energy delivered to the customer. No application was made to the Board prior to

[1] By chapter 318 of the Acts of 1909, on the last business day of each month.

1910 for the examination and test of demand indicators under the claim that they are "meters" within the meaning of the provisions of these sections. The Board had then and still has serious doubts whether the Legislature intended to include "demand indicators" or any similar device by the use of the word "meters."

In 1909 chapter 412 entitled, "An Act relative to the Adjustment, Testing and Sealing of Weighing and Measuring Devices used for Hire or Reward," it is provided as follows: —

Section 1. The provisions of chapter sixty-two of the Revised Laws, relating to the adjustment, testing and sealing of weights, measures and balances shall apply to all weighing and measuring devices used for the purposes of weighing and measuring for hire or reward.

Section 2. A sealer or deputy sealer shall seal such devices when they are tested and found correct, and shall mark, condemn, or seize such devices if found incorrect, in accordance with the provisions of said chapter sixty-two applicable to weights, measures and balances; and all penalties imposed by said chapter for violation of the provisions thereof relative to weights, measures and balances shall also apply to the devices aforesaid.

At the hearings it was suggested that "demand indicators" were "measuring devices" within the meaning of this chapter. The Board was also informed that this claim had been made to the Commissioner of Weights and Measures and that he had been requested to test and seal a demand indicator installed by the Edison Company of Boston upon the premises of one of its customers. The Commissioner of Weights and Measures requested an opinion of the Attorney-General as to his duties and authority with respect to the matter, but no ruling has been made prior to the date of this report.

Conclusions and Recommendations.

At the hearings held by the Board, aside from the representations and arguments presented in behalf of the companies in favor of the continuance and desirability of the use of demand indicators, there was a considerable variance in the view expressed. One of the chief advocates of the legislation proposed at the last session of the General Court, which gave rise to this investigation, favored legislation for the periodic examination, sealing and testing of demand indicators in similar manner to the adjustment, testing and sealing of weights, measures and balances. His complaint was chiefly as to the accuracy of the Wright demand indicators in use

by the Edison Company of Boston and not to the use made of the demand, if correctly determined, in the company's system of rates. Another customer of the same company complained as earnestly, not of the possible inaccuracy of the indicators, but of the system of charging based on the demand of the customer determined by the use of indicators or, for that matter, in any other way. Other large users of electricity supplied by the same company under its system of differentials sent their representative to advocate the continuance of the use of demand indicators and of the demand system of charging, claiming that a differential scale of prices in the sale of electricity is reasonable and necessary. Still others, representing residential sections of the city, upon finding that demand indicators were used by the Edison Company only with respect to customers paying a price per kilowatt hour less than the standard or maximum net price offered to all customers for any use, restricted their opposition to demand indicators to their use in residences.

In the explanation which has been made with respect to the character of these appliances and the purpose for which they are used in the supply of electricity, it is hoped that the Board has made clear that, so far as concerns the customer, they help to ascertain one factor in what is known as a demand system of charge. Where such a system prevails a certain price is made for the customer's demand, however determined, as distinguished from, and usually in addition to, the price made for the electricity consumed measured by a watt-hour recording meter. It is perhaps obvious that where such a system of charge prevails, as the ratio of a customer's consumption to his demand for any given period increases, the average cost per unit of the electricity consumed decreases, and that consequently two customers having the same demands but unequal consumptions of electricity for a given period will pay different average prices for their respective supplies, even though each pays the same price per kilowatt of demand and the same price per kilowatt hour consumed. This is of course describing the system in its essential and simplest form and not with respect to any of the varied applications of the system which appear in the rate schedules of the companies and municipalities using it, especially those of the Edison Company of Boston.

In other words, the use of demand indicators is directly and intimately associated with differential rates for electricity. In

fact there is no occasion for their use except to secure, through the relation of consumption to demand, prices lower than the standard or ordinary prices charged by the company. To put the matter more concretely, the Edison Company of Boston reported that its customers numbered 38,321 on June 30, 1911, and yet it has but 10,745 demand indicators in use. Although the demand in the case of alternating current power customers is for the most part determined otherwise than by demand indicators, it is a fair inference from these figures that nearly 70 per cent. of the company's customers cannot take advantage of the differential rates, but must pay the maximum net price and there is, therefore, no occasion for using demand indicators in supplying them. It follows that of all customers only the comparatively small minority who get the benefit of differential rates, and who to a considerable extent are not dependent upon the companies for their supply, are the ones who are directly interested in the use of demand indicators. The large majority of customers are dependent on the companies for their supply, but are not directly interested in the demand indicator except as by its use or by the prohibition or restriction thereof a lower maximum price for electricity may be secured to them.

In 1908, after an investigation of the Edison Company's rates, in the course of which the demand system, then far more extensively applied by the company, was explained and discussed, the Board, while unable to accept the company's theory in justification for differential rates, recognized the commercial necessity in the present development of the industry of making prices for large or long-hour users of electricity, whether for light or power, sufficiently low to attract the business. The problem of the company was to increase its output without a proportionate increase in investment. This could be accomplished, however, only through far more extended and varied applications of electricity which would bring the company into very direct competition with the cost to prospective customers for light, heat or power otherwise obtainable. In fact, as the Board then stated, the only means by which the average lighting customer may hope to have the price to him materially reduced is through such development of the company's business. The price at which electricity can be offered was and still is an essential feature in the solution of this problem. The Board at that time made no recommendations as to the differential

features of the company's schedules, but recognized "as existing certain economic condictions attending the sale of electricity which, in the interest of the many whose needs and convenience the company should serve, seem to warrant a continuance of certain differences in prices, not as a permanent policy, but until the uniform rate recommended can, from time to time, be safely reduced so low as to be in itself an encouragement to the unrestricted use of electricity for all purposes."

The Board has found no sufficient reason for changing the views then expressed. It has, both with respect to the Edison Company and all others under its supervision, consistently pursued the policy, by the exercise both of its authority and its influence, to force reductions in the maximum prices at which any person in the territory occupied by any company may be supplied with electricity for any use. At the same time it has as consistently declined either to direct changes in, to endorse or to condemn differential prices offered by the companies, insisting however that all prices shall be open to all who may apply for service and that special and secret rates and direct or indirect rebates or preferences shall be discontinued.

The demand system of rates is, of course, not the only system employed for making differential prices. The present way in which the demand system of the Edison Company of Boston is applied is by no means the only way in which such a system may be used. For that matter, demand indicators may not be essential to a demand system of rates, although no satisfactory mechanical substitute for them in that relation is known to the Board. After carefully noting the various schedules of rates of the companies under its supervision and their effect upon revenues, output and operating efficiency, two things are evident, namely, that the men engaged in the business seem agreed upon the present necessity for differential rates, and yet that there is no general agreement among them as to the theory or practice upon which such differential rates should be based. The Board believes that the available experience is not yet sufficient for reaching any just or final conclusion as to the expediency of prohibiting or restricting differential rates. The use of demand indicators, as already pointed out, is so intimately involved in this problem that, for like reasons, it seems at present inexpedient to prohibit or restrict their use. On the other hand, the Board is emphatically of the opinion that

it is not in the public interest that any legislative sanction or approval, directly or indirectly, shall be given to differential rates.

With respect to the "regulation" of demand indicators, the Board has assumed that this expression in the order refers to some means of ensuring their accuracy. The description given of the various types of indicators in use has perhaps made evident some of the difficulties attendant upon applying to them the same rules for adjustment, testing and sealing as apply to weights, measures and balances or even to gas meters. The calibration of the Wright demand indicators prior to installation, for reasons already set forth in the description of this type, fairly constitutes a part of the initial cost of these instruments. The correct adjustment of the other types prior to installation is a necessary incident to their use. But in each instance, owing to the character of the mechanism and the necessary manipulation of the device from time to time by the companies' employees, there is no practicable method of sealing them prior to installation with any assurance that their operation in use may not be altered or affected by changes in surrounding conditions without detection. No satisfactory test of the Wright demand indicators especially can be made upon the premises where installed, due to the impracticability of keeping the conditions necessary for such test constant.

Any provision of law requiring the examination, testing and sealing of demand indicators by a public official must necessarily rest upon a purpose to protect purchasers of electricity from overcharging by the use of indicators allowed to operate incorrectly. To be effective to this end, the method of inspection employed either must reasonably assure the customer that the operation of the indicators after installation by the seller cannot be readily altered or otherwise affected without detection while the same are in use upon his premises, and before another examination and test is made by the public official charged with this duty, or must provide a heavy penalty whenever the seller is found to be employing and maintaining an indicator operating incorrectly and adversely to the customer. The examination of demand indicators made by the Board has convinced it that, if properly constructed, and calibrated, and properly handled and inspected by the companies' employees while in use upon customers' premises, they may be expected to operate correctly within certain reasonable limits. On the other hand, the Board is equally convinced that

it is not practicable to test and seal these appliances in the manner long pursued with respect to gas meters, or to apply the methods employed in the periodic adjustment, examination, testing and sealing of balances, weights and measures. Any attempt to do so would also involve an expense and the organization and maintenance of an inspection force hardly commensurate with the possible good accomplished, especially in view of the limited number of demand indicators in actual use and of the fact that reductions in the maximum net price charged for electricity tend to further reduce this number. It has also been the experience of the Board that the chief complaint is not with the mechanical accuracy of the device itself, but rather with the system of charging in which it is used. No amount of examination and testing will satisfy every customer who complains of a demand recorded for a brief period, of which he has no personal knowledge, but which is made the basis of the charge to be made him for the succeeding year of his supply. This is an inherent difficulty with any system of rates based upon a maximum demand mechanically determined, but the same or greater difficulties arise in ascertaining the demand in any other way known to the Board.

The Board recommends that the provisions of sections 36, 37 and 38 of chapter 121 of the Revised Laws be extended to demand indicators and all other mechanical devices and appliances used in determining the charge to be made by companies and municipalities supplying electricity, save that the examination and test of the same need not be made upon the customer's premises; that a penalty be imposed whenever, upon examination and test, a meter, demand indicator or other device or appliance so used is found to operate or register incorrectly and adversely to the customer; and that it be expressly stipulated that by such action no sanction or justification is intended to be given differential or discriminatory prices for electricity. A bill embodying the Board's recommendation accompanies this report.

Respectfully submitted,

FORREST E. BARKER,
MORRIS SCHAFF,
ALONZO R. WEED,
Board of Gas and Electric Light Commissioners.

AN ACT TO PROVIDE FOR THE INSPECTION OF DEMAND INDICATORS.

SECTION 1. The provisions of sections thirty-six, thirty-seven and thirty-eight of chapter one hundred and twenty-one of the Revised Laws and of all acts in amendment thereof and in addition thereto shall apply to demand indicators, so called, and any other devices or appliances installed by an electric company upon the premises of any of its customers and used by such company for the purpose of determining the charge to such customer for its service. Nothing herein contained shall be held to authorize or justify differential prices for electricity supplied by such company.

SECTION 2. Whoever being engaged in the sale of electricity maintains upon the premises of a customer a meter, demand indicator or other mechanical device or appliance for the purpose of determining the charge to be made for electricity supplied to such customer, which meter, demand indicator or other mechanical device or appliance is found upon examination and test, as provided in section thirty-six of chapter one hundred and twenty-one of the Revised Laws, to register incorrectly as against such customer, shall for each offence be punished by a fine of not more than twenty-five dollars.

SECTION 3. All provisions of law inconsistent herewith are hereby repealed.

SECTION 4. This act shall take effect upon its passage.

APPENDICES.

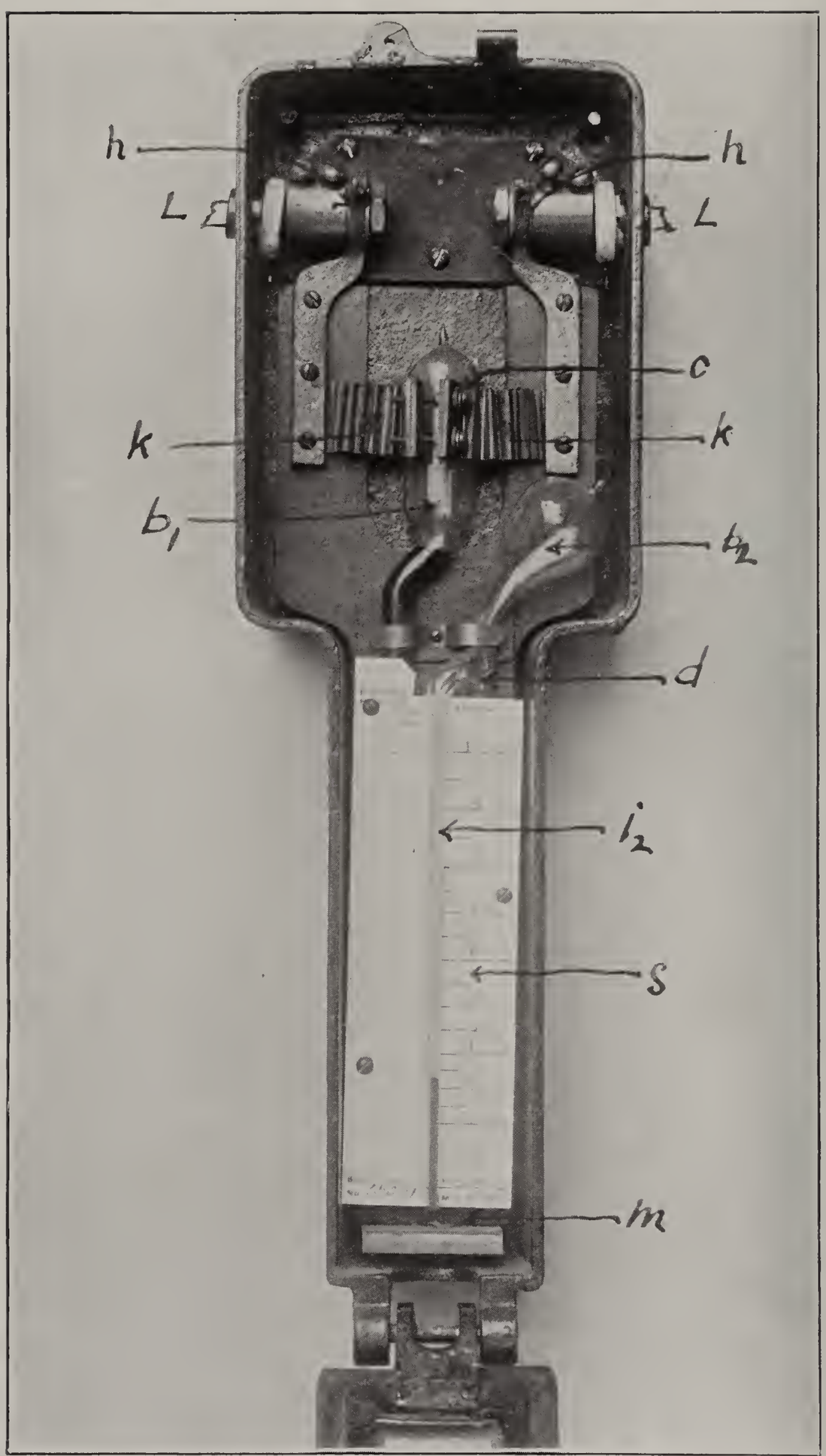


Fig. 1. — Wright Maximum Demand Indicator.

Appendix A.

REPORT TO BOARD OF GAS AND ELECTRIC LIGHT COMMISSIONERS ON MAXIMUM DEMAND INDICATORS IN USE BY THE EDISON ELECTRIC ILLUMINATING COMPANY OF BOSTON, DECEMBER, 1911, BY F. A. LAWS.

In cases where it is necessary to determine a customer's maximum demand, the practice of the Edison Electric Illuminating Company of Boston is as follows: —

All demands on direct current services and all demands on alternating current services, if the load be noninductive (that is, where alternating current motors, rectifiers, etc., are not used), are determined by means of the Wright Maximum Demand Indicator *except* in cases where electricity is sold under schedule D of the schedule of rates published by that company June 1, 1910 (Appendix B).

In all cases where schedule D is in force, for either direct or alternating current services, and for all alternating current power above 50 kilowatts, the Ingalls Relay Demand Indicator is used.

In general, for alternating current power under 50 kilowatts no permanent device is installed; the demand is commonly determined by timing, at intervals, the regularly installed watt-hour meter with a stop watch while the machinery is running at its normal maximum, or else an Ingalls Relay Demand Indicator, is temporarily installed and the demand so determined. Occasionally, however, this indicator is made a permanent fixture. There are, therefore, two devices in use by this company for determining maximum demands: —

1. The Wright Maximum Demand Indicator.
2. The Ingalls Relay Demand Indicator.

The Wright Maximum Demand Indicator.

This indicator may be looked upon as a registering differential thermometer, one bulb of which is heated by the passage of the current through a suitable heater coil which closely surrounds it.

The internal appearance of the indicator as made in the smaller sizes, up to and including 25 amperes, is shown in Fig. 1.

The essential working parts are the indicator tube, with its attached index tube (i_2), the scale (s) and the heater strips (c). In the small sizes (up to and including 25 amperes) the customer's entire current is taken in through the leads (L,L), and to the heater strips via the spring hinges (h) and flexible connecting strips (k).

The Indicator Tube. — The indicator tube (see Fig. 2) is of glass, annealed so that it will bear handling and not be subject to changes due to stresses in the glass; the two bulbs (b_1 and b_2) which are nearly equal in volume, contain air, the U tube connecting them contains concentrated sulphuric acid in such an amount and so adjusted in the tube that when the indicator is cold and set ready to begin to operate, the level of the liquid is at d, so that it is just on the point of flowing into the index tube (i_2). Sulphuric acid is used because it "wets" the glass, is very heavy, flows readily, is hygroscopic and expands comparatively little with rise of temperature. To prevent accidental transfer of air from b_1 to b_2 or *vice versa*, especially when the indicator is set, the tube is constricted to a capillary at g and g′ and two traps are provided at t and t′.

Heater Strips. — The heater strips are of an alloy of high resistivity, the resistance of which is but little affected by temperature; the strips are of very thin metal and are made to closely embrace the cylindrical glass bulb (b_1) by means of screw clamps. (See Fig. 3.) In the small-sized indicators, where it is necessary to carry the heater strips around the bulb a number of times, a non-inductive form, shown at A in Fig. 3, is used. The object of this construction is to prevent the turns drawing together when a short circuit occurs; if this should happen the strips would very likely be burned out or their intimacy of contact with the glass so altered that an error would be introduced. The corrugated copper terminals form somewhat flexible electrical connections to the heater proper. In indicators having a range of 35 amperes and above, shunts are used, the heater strips being of the 15-ampere type.

Setting and Operation. — The indicator is set by raising the lower end of the tube board (m), on which the above described members are mounted, until it is somewhat above the spring hinges (h) on which it is pivoted. This allows the liquid in the index tube (i_2) to drain back into the U tube; when thoroughly drained and the board is lowered to its normal position, the U tube is filled with liquid up to d.

If a current is now sent through the heater strips, the air in b_1 is heated, and expands, causing the liquid to flow slowly into the index tube (i_2) which is in front of the graduated scale; the flow will continue

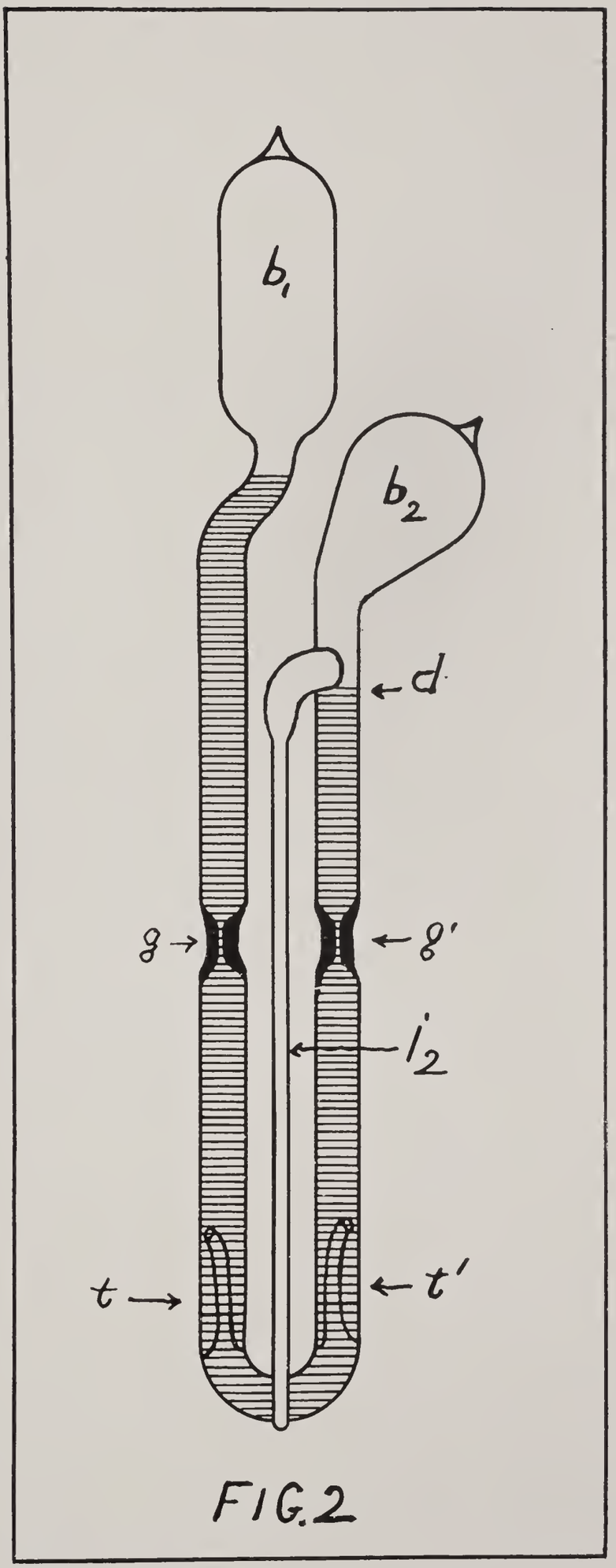
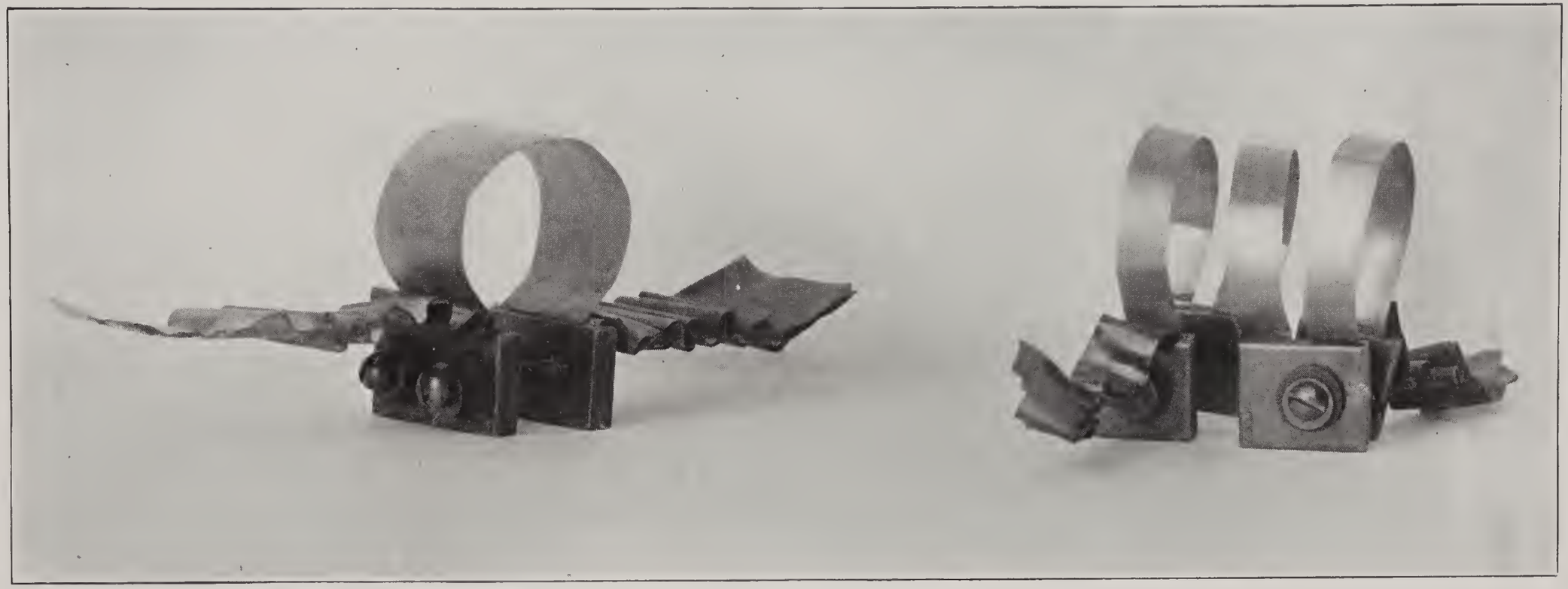
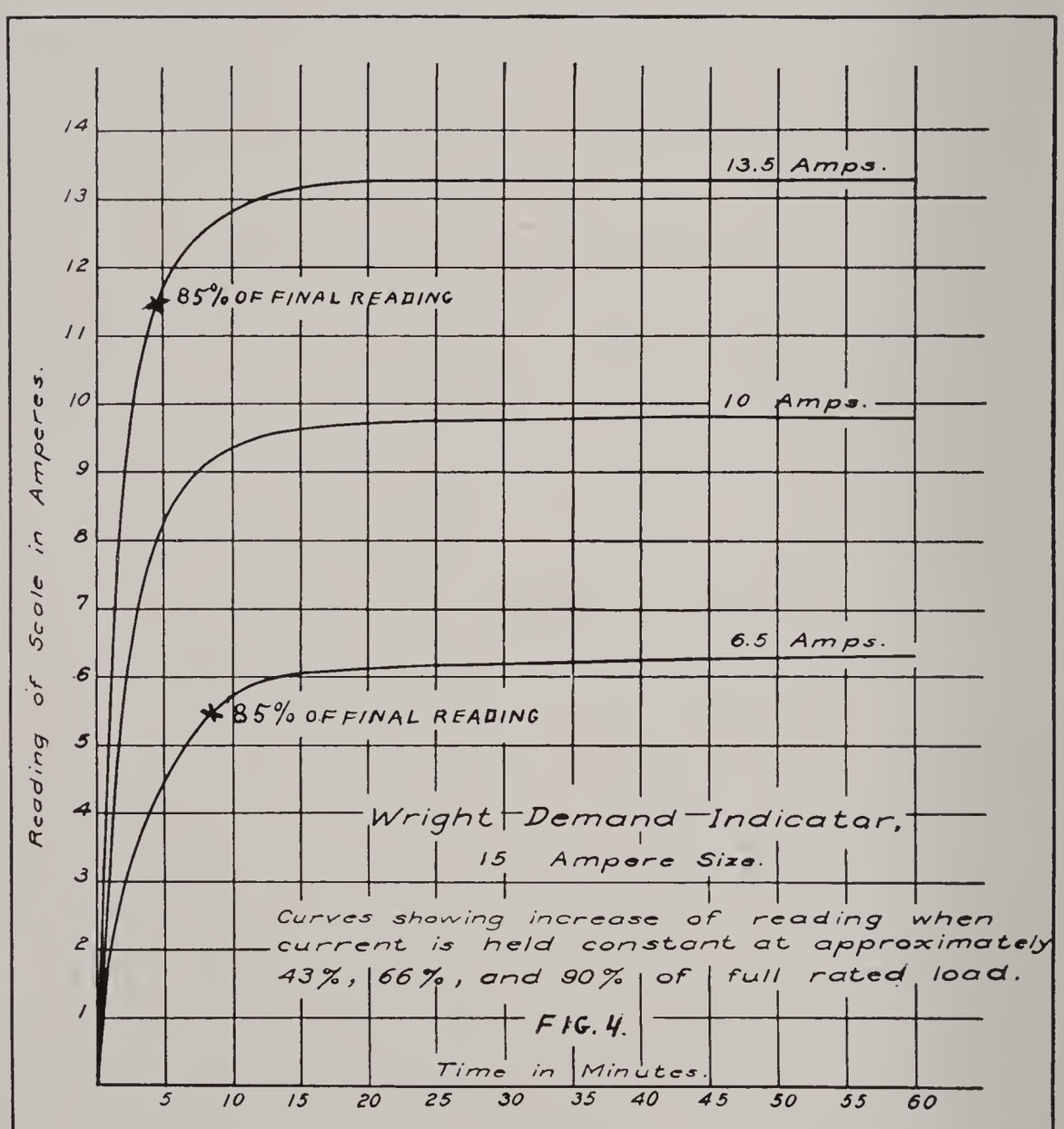


FIG. 2



B A

Fig. 3.


Reading of Scale in Amperes.
14
13
12
11
10
9
8
7
6
5
4
3
2
1
13.5 Amps.
85% OF FINAL READING
10 Amps.
6.5 Amps.
85% OF FINAL READING
Wright Demand Indicator,
15 Ampere Size.
Curves showing increase of reading when current is held constant at approximately 43%, 66%, and 90% of full rated load.
FIG. 4.
Time in Minutes.
5
10
15
20
25
30
35
40
45
50
55
60

until the permanent state of temperature corresponding to that particular current is reached.

Time-lag. — Owing to the heat capacity of the strips, the glass bulb, etc., and the poor thermal conductivity of the glass, the response of the indicator to the increase of current is sluggish; this lagging of the reading behind the increase of current is essential to the successful operation of any such device, for it must not take cognizance of currents above the normal, which last for only a very short time. The indication desired is that due to the *sustained* maximum. Fig. 4 shows this gradual increase of reading when the current is kept constant. Another point may be noted: after the device has cooled down, owing to shutting off the current, there will be no increase of reading when a current slightly larger than that previously registered is turned on until the larger current has been maintained for a time longer than the normal time-lag of the indicator; for that time must elapse before there has been sufficient expansion of the air in b_1 to cause the liquid to again begin to flow into the index tube. (This is illustrated in Fig. 5.) Curve A shows the normal rise of the indication, when, after the device has been set, the current is maintained at 10 amperes. After the current has been thrown off and the indicator allowed to cool thoroughly, a run at 10.5 amperes gives curve B (the indicator *not* being reset).

It is intended that approximately 90 per cent. of the full load registration be accomplished in four minutes, and the entire registration in about forty minutes. Fig. 4 shows how a particular instrument responded to the current.

It will be noted from Fig. 4 that the rise to a fair approximation to the final reading, say 85 per cent. of it, occurs more abruptly when the indicator is worked at about its full capacity than when it is lightly loaded. Fig. 6 illustrates this point; a 50 and a 100 ampere indicator were tested in series at 45 amperes. Of course each indicator has its characteristic rate of response to the current.

Owing to differences in the tubes, it is impracticable to print the scales, for each must be graduated by experiment to fit the particular tube to which it is applied. It is the practice of the Edison Company to determine either 4 or 5 points by passing measured currents through the indicator for a sufficient time, and then marking on the scale the corresponding heights of the liquid in the index tube (i_2); the subdivision is done mechanically. Samples of the scales used by this company are shown in Fig. 7; the points which are experimentally determined are marked by a heavy dot.

The indicators are connected in circuit as shown in Fig. 8.

It is the present practice of the Edison Company to bring in yearly for test and whatever adjustment is necessary, one-fourth of the Wright Demand Indicators which it has installed on its lines. The work is usually done in the eight months, March–October, inclusive.

Tests. — The standard specifications for the purchase of Wright Demand Indicators include this statement as to the accuracy which the device should possess: —

	Per Cent.
At full scale,	4
At four-fifths scale,	5
At three-fifths scale,	$6\frac{2}{3}$
At two-fifths scale,	10
At one-fifth scale,	20

The understanding is that the average accuracy of any 10 instruments shall be 3 per cent. or better at full scale reading at the time of purchase.

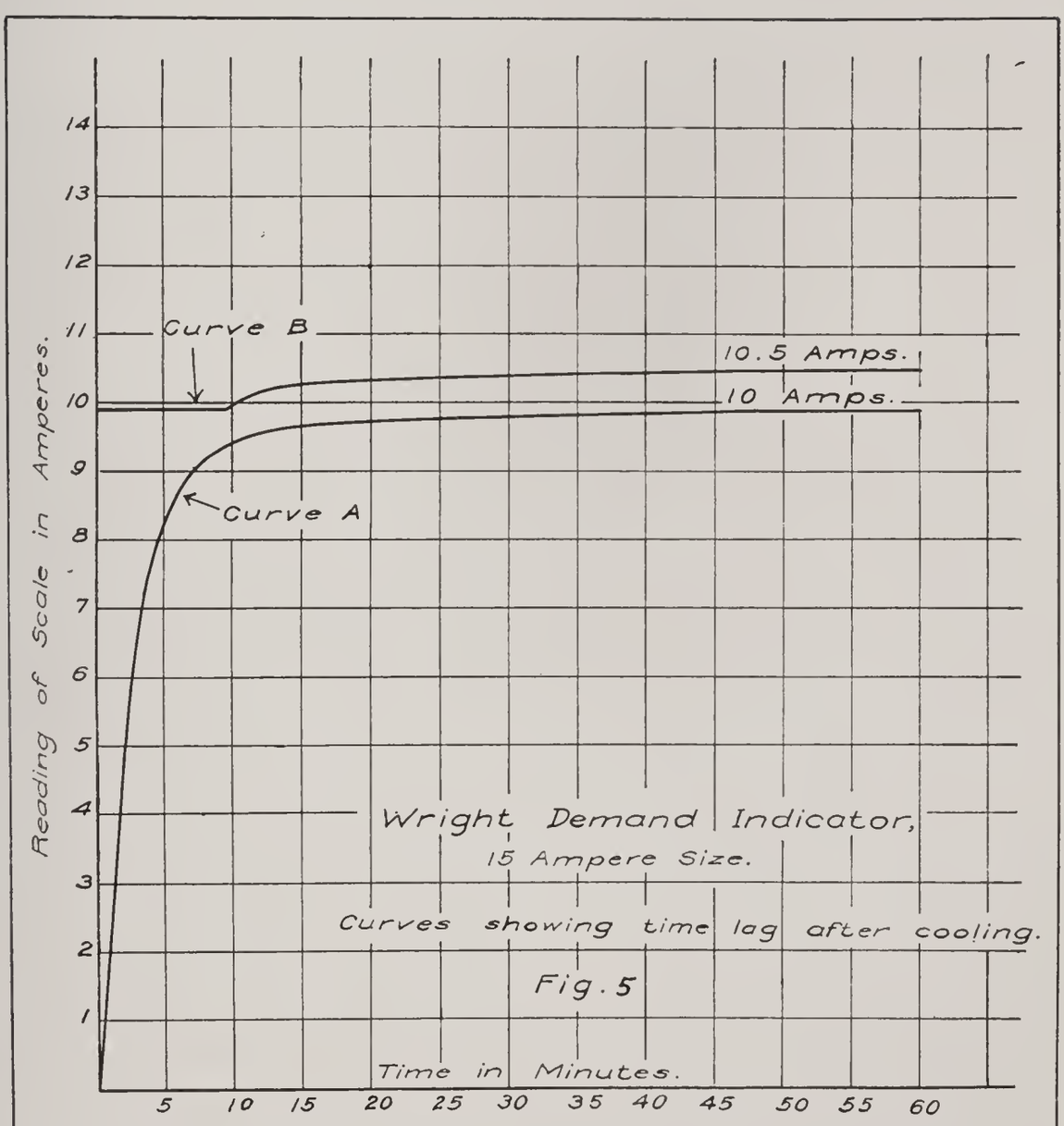
The Edison Company has installed on its lines about 10,600 Wright Demand Indicators, of which approximately 99 per cent. are included in the sizes from 5 amperes to 200 amperes, inclusive, and the 300-ampere size. From these sizes the indicators to be tested were selected. The remaining 1 per cent. includes indicators of various capacities up to 3,000 amperes.

The indicators to be tested were selected as follows: I was given access to the cases in which the meter readers' cards are filed. From these I drew cards at random until the desired number of indicators of any specified size was reached. In the drawing, care was taken to retain only indicators which were actually used by the company in computing the bills of customers. Light and power and alternating as well as direct current services were represented in the selection.

The numbers drawn as above were recorded, and the indicators removed from the customers' premises, either in my presence or in the presence of my representative. They were immediately transferred to the Standardizing Laboratory of the Massachusetts Institute of Technology, where the tests were made.

At the laboratory the indicators of a given size were set up and connected in series, currents, either direct or alternating as the case required, and of the proper magnitude were sent through them and maintained constant until the readings assumed their ultimate values. The currents were measured by the use of standards certified by the United States National Bureau of Standards at Washington, D. C.

The points selected for calibration were: first, 20 per cent. and 90 per cent. of the full scale reading, the former because it is usually the


Reading of Scale in Amperes.
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Curve B
10.5 Amps.
10 Amps.
Curve A
Wright Demand Indicator,
15 Ampere Size.
Curves showing time lag after cooling.
Fig. 5
Time in Minutes.
5
10
15
20
25
30
35
40
45
50
55
60

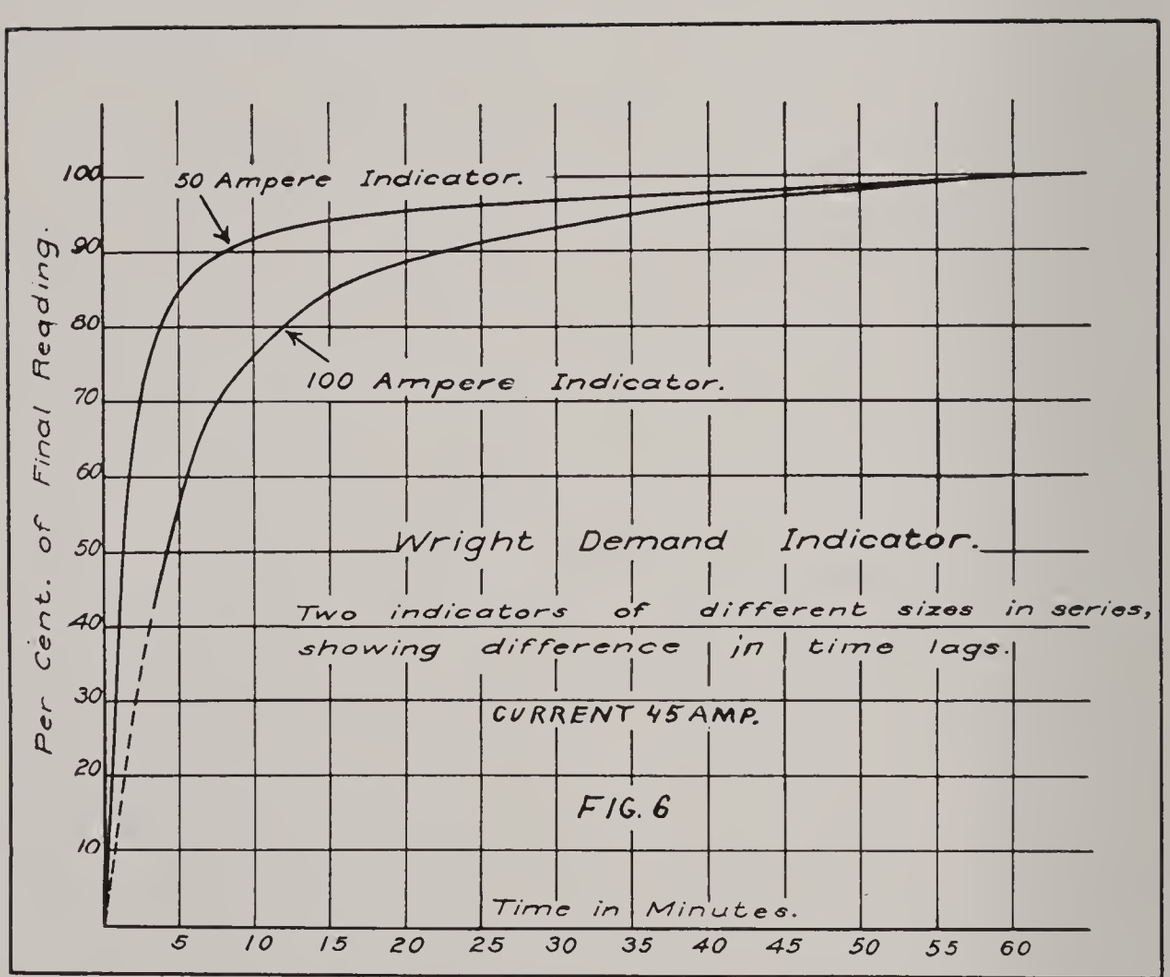

50 Ampere Indicator.
100 Ampere Indicator.
Per Cent. of Final Reading.
100
90
80
70
60
50
40
30
20
10
5
10
15
20
25
30
35
40
45
50
55
60
Time in Minutes.
Wright Demand Indicator.
Two indicators of different sizes in series, showing difference in time lags.
CURRENT 45 AMP.

FIG. 6

first mark on the scale, the latter because it is desirable to be able to state the inaccuracy at the upper end of the scale if the indicator should register too much; second, two intermediate points at about 43 per cent. and 66 per cent. were taken, thus dividing the interval between 20 per cent. and 90 per cent. about equally. Tests were made at these four points and then, in order to obtain a check measurement, the whole series was repeated. All tests were made at a room temperature of 68 degrees F., unless otherwise specified.

The results obtained are given on pages 27–32, which are the summaries of the percentage registration tables found on pages 33–36.

As the 20 per cent. load mark is the first one on the scale, no numerical reading is possible unless the indicator is correct or reads too much; so on page 27 it is simply noted whether the reading is too large, correct or too small. The average registration of those indicators which register too much at this point is 113.5 per cent., which is the average of the figures appearing on page 33. If those registering correctly be included the average is 108.7 per cent. The readings at the lower end of the scale are considerably influenced by temperature; for instance, four indicators of 35-amperes capacity, were set at 68 degrees F., and then the temperature raised to 104 degrees F. and kept there for four hours; no current was sent through the indicators. The average rise of the liquid in the indicator tubes was .52 inch, which roughly corresponds to a change of reading of 5 amperes at this point. These extremely low readings are not, however, of as great importance as those at the upper end of the scale. For example, it happened that the average percentage reading of the indicators when removed for test was approximately 60 per cent., with an occasional value falling as low as 30 per cent. The effect of temperature becomes smaller as the readings increase.

This is more fully illustrated by the following tests: Two indicators, one of 5, the other of 10, amperes' capacity, were used. They were placed in a suitable chamber in which were heating coils and a fan to circulate the air. The temperature being originally at 68 degrees F. was raised to 104 degrees F., no current being sent through the indicators. The rise of liquid in the index tube was for the 5-ampere indicator .38 inches, for the 10-ampere indicator .50 inches.

The temperature was maintained constant for four hours at 104 degrees F., the fan being kept running; at the end of this time the 20 per cent. load test was begun, the other tests followed as usual and the results are shown in Fig. 9. It will be seen that the low readings are very considerably affected, that the percentage error decreases with an increase of load, and that each instrument has its own character-

istic behavior. The results given by the curves are the averages obtained from three separate tests.

The results at the other loads are stated numerically on pages 28–29, where are exhibited the number of indicators falling into these groups: —

Indicators registering 90 per cent. and less
Indicators registering from 90.1 to 94.9 per cent. inclusive.
Indicators registering from 95 to 98 per cent. inclusive.
Indicators registering from 98.1 to 101.9 per cent. inclusive.
Indicators registering from 102 to 105 per cent. inclusive.
Indicators registering from 105.1 to 109.9 per cent. inclusive.
Indicators registering 110 per cent. and more.

From these tables it will be seen that —

At 20 Per Cent. Load.— Approximately 45 per cent. of the indicators register too much with an average excess registration of 13.5 per cent.

Approximately 31 per cent. of the indicators register too little.

Approximately 25 per cent. of the indicators register correctly.

The average excess registration of the indicators which register correctly and too much is 8.7 per cent.

At 43 Per Cent Load.— Approximately 72 per cent. of the indicators register between 95 and 105 per cent.

Approximately 19 per cent. of the indicators register more than 105 per cent.

Approximately 10 per cent. of the indicators register less than 95 per cent.

Average registration of 81 meters at 43 per cent. load is 101.3 per cent.

At 66 Per Cent. Load.— Approximately 84 per cent. of the indicators register between 95 and 105 per cent.

Approximately 11 per cent. of the indicators register more than 105 per cent.

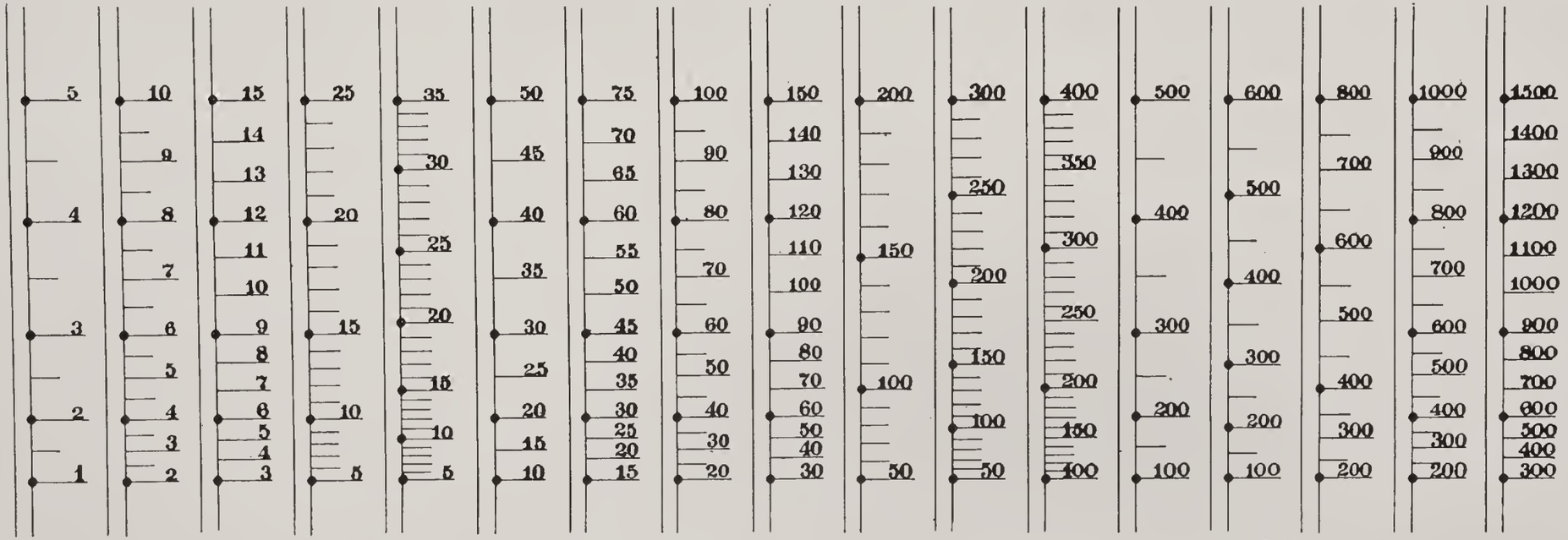
Approximately 5 per cent. of the indicators register less than 95 per cent.

Average registration of 81 meters at 66 per cent. load is 101.1 per cent.

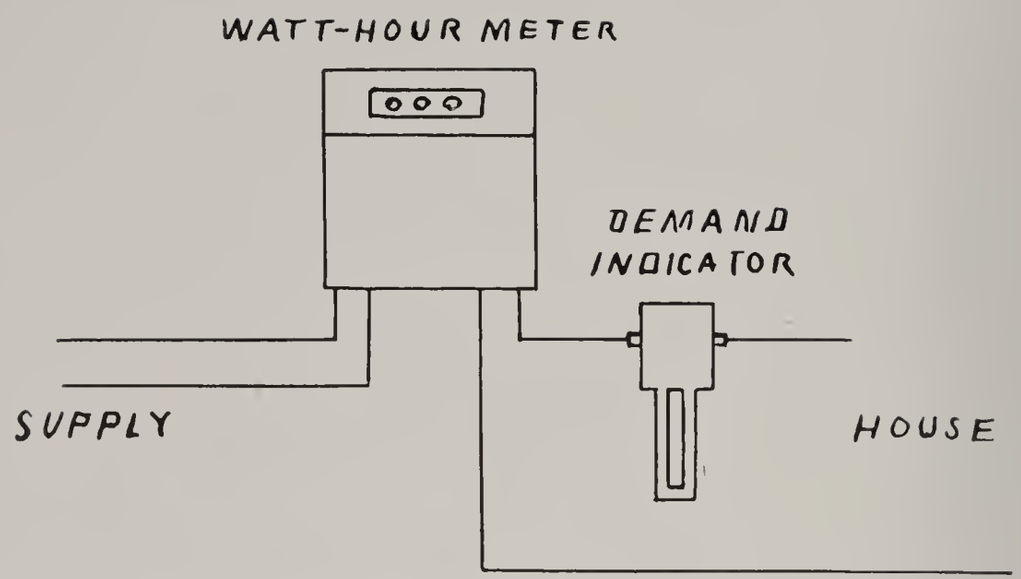
At 90 Per Cent. Load.— Approximately 82 per cent. of the indicators register between 95 and 105 per cent.

Approximately 14 per cent. of the indicators register more than 105 per cent.

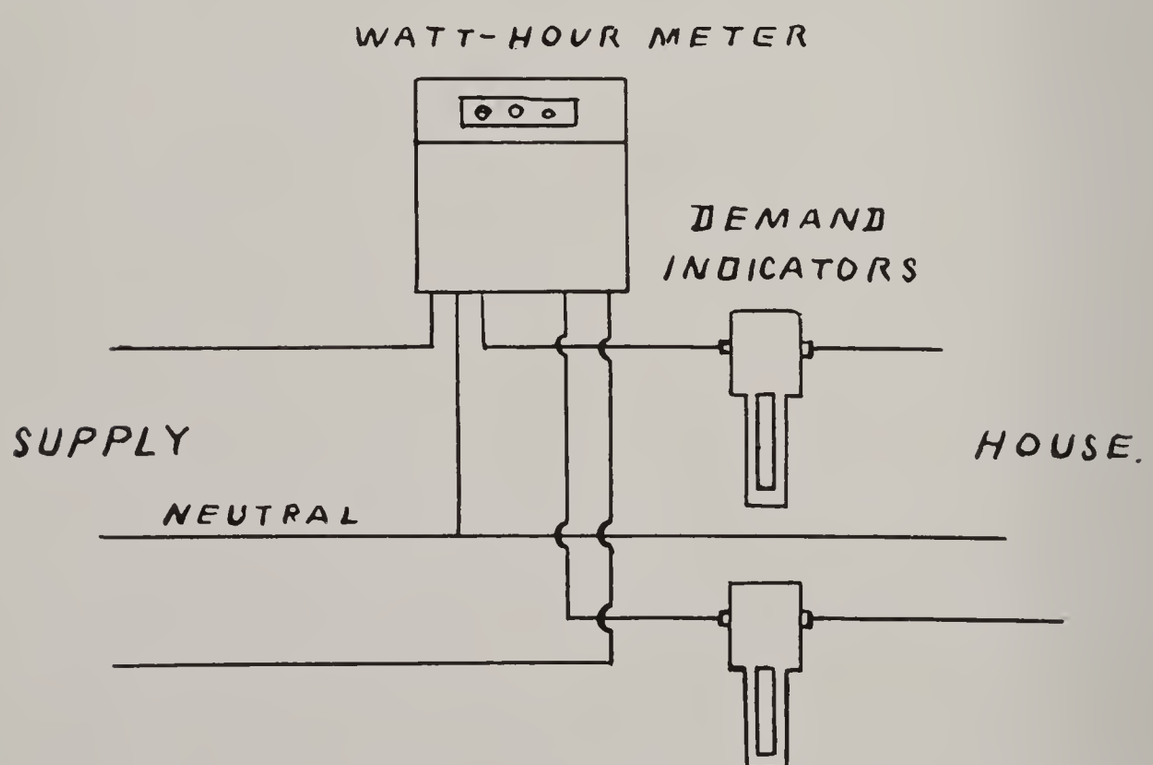
Approximately 5 per cent. of the indicators register less than 95 per cent.



SCALES FOR DISCOUNT INDICATORS
FIG. 7.



FOR TWO WIRE SERVICE.



FOR THREE WIRE SERVICE

FIG 8

Average registration of 81 meters at 90 per cent. load is 101.1 per cent.

References to pages 33–36 will show that there are occasional wide deviations from the average values. For instance, among the 150 ampere indicators tested at 90 per cent. load, there is one with a registration of 114.8 per cent., and one with a registration of 110.4 per cent. All the others average about 103 per cent.

Results of Tests on 81 Wright Demand Indicators classified in Groups according to the Magnitude of the Errors and the Sizes of the Indicators.

At 20 Per Cent. Load.

Rating of Indicators (Amperes).	Number of Indicators which register too —		Number which register correctly.
	Much.	Little.	
5,	6	2	0
10,	3	3	4
15,	5	3	2
25,	5	4	1
35,	1	3	0
50,	7	2	1
75,	3	4	3
100,	3	1	1
150,	3	0	4
200,	0	2[1]	4[1]
300,	0	1	0
Totals,	36	25	20

[1] At 25 per cent load being first mark on scale of this indicator.

44.5 per cent. of the indicators register too much. The average excess registration is 13.5 per cent.

30.9 per cent. of the indicators register too little.

24.7 per cent. of the indicators register correctly.

Average excess registration of indicators which register correctly and too much, 8.7 per cent.

RESULTS OF TESTS ON 81 WRIGHT DEMAND INDICATORS — *Continued.*

At 43 Per Cent. Load.

RATING OF INDICATORS (AMPERES).	NUMBER OF INDICATORS REGISTERING —						
	110 Per Cent. and More.	109.9–105.1 Per Cent. inclusive.	105–102 Per Cent. inclusive.	101.9–98.1 Per Cent. inclusive.	98–95 Per Cent. inclusive.	94.9–90.1 Per Cent. inclusive.	90 Per Cent. and Less.
5, . . .	0	0	2	4	2	0	0
10, . . .	0	2	2	4	0	1	1
15, . . .	0	0	3	3	4	0	0
25, . . .	0	0	2	6	1	1	0
35, . . .	1	0	2	0	0	1	0
50, . . .	3	3	2	1	0	1	0
75, . . .	1	0	1	4	4	0	0
100, . . .	0	1	2	2	0	0	0
150, . . .	1	3	0	2	0	1	0
200, . . .	0	0	0	5	0	1	0
300, . . .	0	0	0	0	0	0	1
Totals, .	6	9	16	31	11	6	2

71.6 per cent. of the indicators register between 95 per cent. and 105 per cent.
18.5 per cent. of the indicators register more than 105 per cent.
9.9 per cent. of the indicators register less than 95 per cent.

At 66 Per Cent. Load.

RATING OF INDICATORS (AMPERES).	NUMBER OF INDICATORS REGISTERING —						
	110 Per Cent. and More.	109.9–105.1 Per Cent. inclusive.	105–102 Per Cent. inclusive.	101.9–98.1 Per Cent. inclusive.	98–95 Per Cent. inclusive.	94.9–90.1 Per Cent. inclusive.	90 Per Cent. and Less.
5, . . .	0	0	1	2	4	1	0
10, . . .	0	1	3	4	1	1	0
15, . . .	0	0	2	2	6	0	0
25, . . .	0	0	1	7	1	1	0
35, . . .	1	0	1	1	1	0	0
50, . . .	2	1	4	3	0	0	0
75, . . .	1	0	4	3	2	0	0
100, . . .	0	1	2	2	0	0	0
150, . . .	1	1	2	2	1	0	0
200, . . .	0	0	2	4	0	0	0
300, . . .	0	0	0	0	0	1	0
Totals, .	5	4	22	30	16	4	0

84.0 per cent. of the indicators register between 95 per cent. and 105 per cent.
11.1 per cent. of the indicators register more than 105 per cent.
5.0 per cent. of the indicators register less than 95 per cent.

RESULTS OF TESTS ON 81 WRIGHT DEMAND INDICATORS — *Concluded.*

At 90 Per Cent. Load.

RATING OF INDICATORS (AMPERES).	NUMBER OF INDICATORS REGISTERING —						
	110 Per Cent. and More.	109.9–105.1 Per Cent. inclusive.	105–102 Per Cent. inclusive.	101.9–98.1 Per Cent. inclusive.	98–95 Per Cent. inclusive.	94.9–90.1 Per Cent. inclusive.	90 Per Cent. and Less.
5, . . .	0	0	1	5	1	1	0
10, . . .	1	0	1	5	2	1	0
15, . . .	0	0	1	7	2	0	0
25, . . .	0	0	1	6	2	1	0
35, . . .	0	2	0	2	0	0	0
50, . . .	0	3	4	2	1	0	0
75, . . .	1	0	1	6	2	0	0
100, . . .	1	1	0	3	0	0	0
150, . . .	2	0	3	0	2	0	0
200, . . .	0	0	3	3	0	0	0
300, . . .	0	0	0	0	0	1	0
Totals, .	5	6	15	39	12	4	0

81.5 per cent. of the indicators register between 95 per cent. and 105 per cent.
13.6 per cent. of the indicators register more than 105 per cent.
5.0 per cent. of the indicators register less than 95 per cent.

RESULTS OF TESTS ON 81 WRIGHT DEMAND INDICATORS, AS SHOWN BY THE AVERAGE VALUES, CLASSIFIED ACCORDING TO SIZES OF THE INDICATORS.

Average Results from 8 5-Ampere Indicators.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20, ...	.066	–	6.3	–
43, ...	–	.016	–	.7
66, ...	–	.050	–	1.5
90, ...	–	.045	–	1.0

RESULTS OF TESTS ON 81 WRIGHT DEMAND INDICATORS, AS SHOWN BY THE AVERAGE VALUES — *Continued.*

Average Results from 10 10-Ampere Indicators.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20,	–	–	–	–
43,	.015	–	.3	–
66,	.022	–	.3	–
90,	–	.004	0.0	0.0

Average Results from 10 15-Ampere Indicators.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20,	–	–	–	–
43,	–	.042	–	.6
66,	–	.099	–	1.0
90,	–	.13	–	1.0

Average Results from 10 25-Ampere Indicators.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20,	–	–	–	–
43,	–	.046	–	.4
66,	–	.034	–	.2
90,	–	.27	–	1.2

RESULTS OF TESTS ON 81 WRIGHT DEMAND INDICATORS, AS SHOWN BY THE AVERAGE VALUES — *Continued.*

Average Results from 4 35-Ampere Indicators.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20,	–	–	–	–
43,	.54	–	3.6	–
66,	.84	–	3.6	–
90,	1.30	–	4.1	–

Average Results from 10 50-Ampere Indicators.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20,	–	–	–	–
43,	1.59	–	7.3	–
66,	1.29	–	3.9	–
90,	1.55	–	3.4	–

Average Results from 10 75-Ampere Indicators.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20,	–	–	–	–
43,	.35	–	1.1	–
66,	.90	–	1.8	–
90,	1.05	–	1.5	–

RESULTS OF TESTS ON 81 WRIGHT DEMAND INDICATORS, AS SHOWN BY THE AVERAGE VALUES — *Concluded.*

Average Results from 5 100-Ampere Indicators.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20, ...	–	–	–	–
43, ...	1.09	–	2.5	–
66, ...	1.40	–	2.1	–
90, ...	3.44	–	3.8	–

Average Results from 7 150-Ampere Indicators.

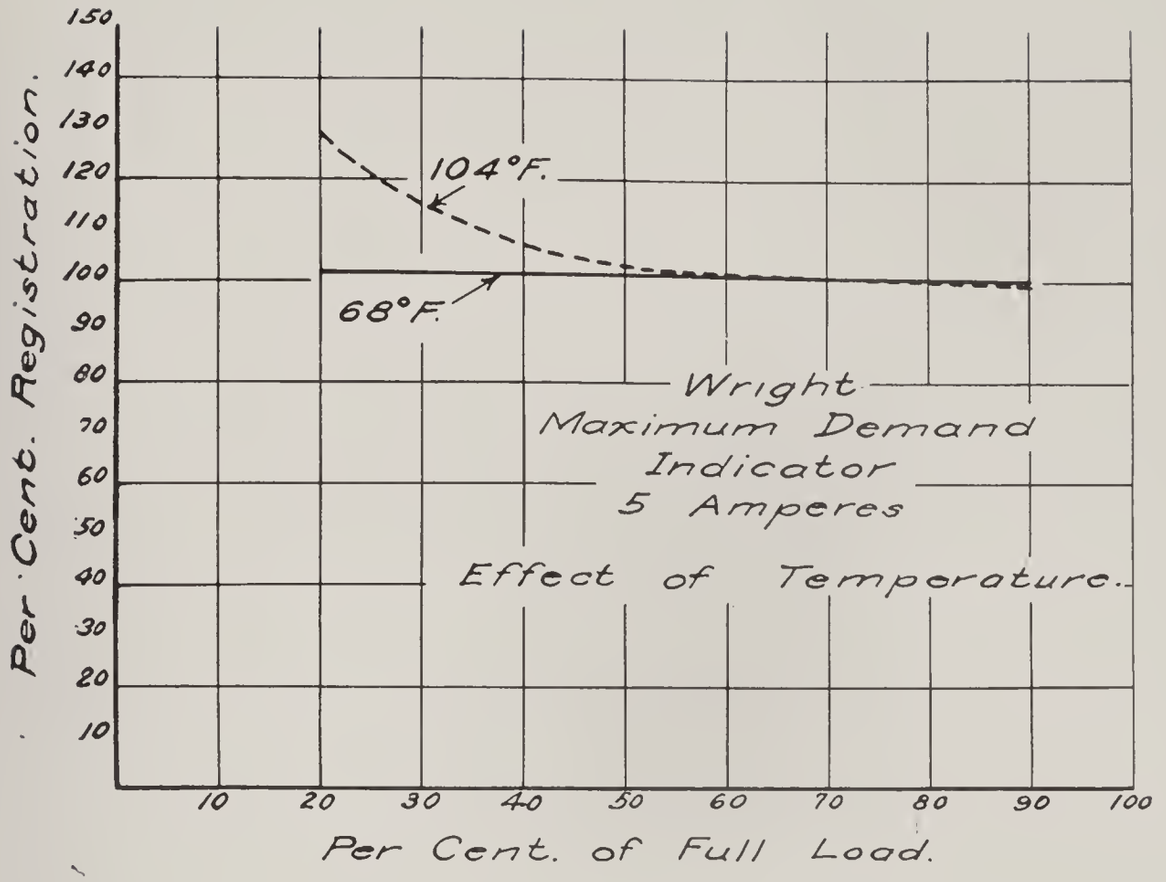
PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20, ...	–	–	–	–
43, ...	2.3	–	3.6	–
66, ...	3.3	–	3.3	–
90, ...	5.1	–	3.8	–

Average Results from 6 200-Ampere Indicators.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20, ...	–	–	–	–
43, ...	–	.7	–	.8
66, ...	2.3	–	1.8	–
90, ...	4.0	–	2.2	–

Results from 1 300-Ampere Indicator.

PER CENT. OF FULL LOAD.	INDICATORS REGISTER TOO —		CORRESPONDING PER CENT. TOO —	
	Much by — Amperes.	Little by — Amperes.	Much.	Little.
20, ...	–	–	–	–
43, ...	–	18.5	–	14.2
66, ...	–	18.0	–	9.0
90, ...	–	24.0	–	8.8


Per Cent. Registration.
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
104°F.
68°F.
Wright
Maximum Demand
Indicator
5 Amperes
Effect of Temperature.
10
20
30
40
50
60
70
80
90
100
Per Cent. of Full Load.

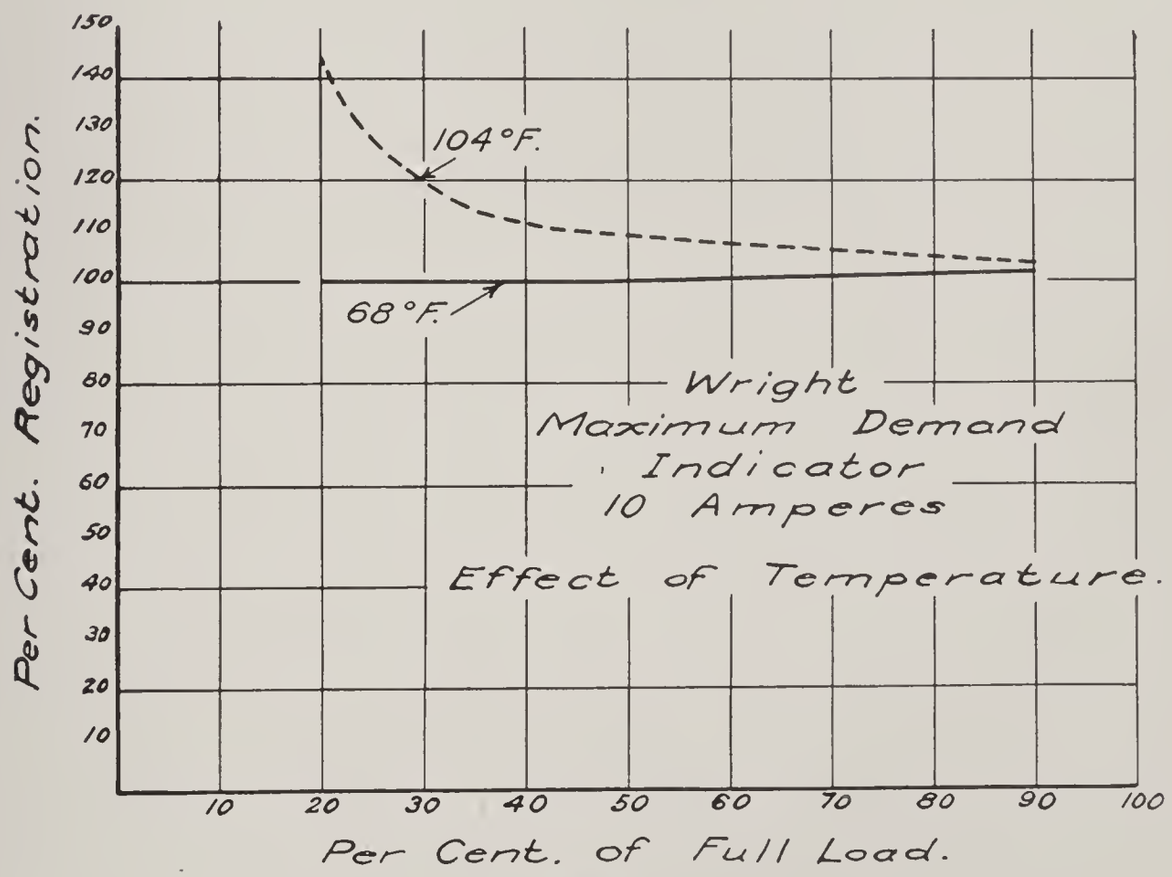

Per Cent. Registration.
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
104°F.
68°F.
Wright
Maximum Demand
Indicator
10 Amperes
Effect of Temperature.
10
20
30
40
50
60
70
80
90
100
Per Cent. of Full Load.

Fig. 9.

Percentage Registration of Wright Maximum Demand Indicators.

At 20 Per Cent. Load.

Rating of Indicators (Amperes).	Registering too Much.	Registration (Per Cent.).	Registering too Little.	Registration (Per Cent.).	Registering correctly.
5,	No. 90493	101.9	No. 12885	95.2	–
	12441	125.7	95049	95.2	–
	14409	102.0	–	–	–
	11	114.3	–	–	–
	12613	104.8	–	–	–
	14545	111.4	–	–	–
10,	No. 93352	110.0	No. 9838	–	No. 15071
	96157	102.5	14285	–	8815
	9431	115.0	93718	–	15464
	–	–	–	–	13718
15,	No. 7208	118.4	No. 5603	–	No. 6538
	11689	121.7	5165	–	15650
	13819	115.0	5551	–	–
	2757	121.7	–	–	–
	2871	103.3	–	–	–
25,	No. 91286	113.0	No. 4785	–	No. 3729
	6992	102.0	4362	–	–
	2563	111.2	6974	–	–
	473	112.2	–	–	–
	9110	106.3	2981	98.4	–
35,	No. 11880	101.4	No. 12448	–	–
	–	–	10961	–	–
	–	–	3978	–	–
50,	No. 11858	117.5	No. 90764	–	No. 1431
	7661	170.0	12030	–	–
	4431	132.5	–	–	–
	3961	115.0	–	–	–
	6440	126.0	–	–	–
	3484	115.0	–	–	–
	10580	112.5	–	–	–
75,	No. 10984	113.3	No. 10914	–	No. 3004
	2824	113.3	3674	–	4582
	142	103.3	11342	–	4872
	–	–	94459	–	–
100,	No. 3824	113.8	No. 90357	–	No. 1493
	7562	111.2	–	–	–
	7563	106.1	–	–	–
150,	No. 90459	106.7	–	–	No. 13811
	90460	105.0	–	–	8376
	2098	111.7	–	–	13555
	–	–	–	–	2096
200,	–	–	No. 13808	–	No. 90236
	–	–	11048	–	230
	–	–	–	–	237
	–	–	–	–	298
300,	–	–	No. 11686	–	–

PERCENTAGE REGISTRATION OF WRIGHT MAXIMUM DEMAND INDICATORS — *Continued.*

At 43 Per Cent. Load.

RATING OF INDICATORS (AMPERES).	Registering too Much.	Registration (Per Cent.).	Registering too Little.	Registration (Per Cent.).	Registering correctly.
5,	No. 90493	102.3	No. 12441	98.6	–
	14545	104.5	12885	96.4	–
	–	–	14409	98.6	–
	–	–	11	98.6	–
	–	–	95049	96.4	–
	–	–	12613	98.6	–
10,	No. 93352	106.3	No. 9838	89.5	No. 15071
	96157	104.0	14285	98.1	–
	8815	101.2	15464	94.6	–
	9431	108.2	94718	99.3	–
	13718	102.3	–	–	–
15,	No. 7208	103.1	No. 5603	99.2	–
	11689	100.8	5165	96.9	–
	13819	102.6	6538	95.7	–
	2757	104.6	15650	95.7	–
	–	–	5551	95.4	–
	–	–	2871	99.5	–
25,	No. 91286	101.1	No. 4785	92.6	–
	3729	103.2	4362	98.2	–
	6992	101.4	6974	96.0	–
	2563	104.4	473	99.9	–
	2981	100.2	9110	98.8	–
35,	No. 12448	115.8	No. 10961	91.1	–
	11880	104.0	–	–	–
	3978	103.3	–	–	–
50,	No. 90764	103.5	No. 12030	92.6	–
	11858	107.6	–	–	–
	7661	121.5	–	–	–
	4431	118.1	–	–	–
	3961	108.8	–	–	–
	6440	101.4	–	–	–
	3484	111.1	–	–	–
	10580	106.5	–	–	–
	1431	102.4	–	–	–
75,	No. 3004	100.8	No. 10914	96.9	–
	4582	101.5	3674	96.9	–
	4872	101.5	94459	96.2	–
	10984	103.1	–	–	–
	11342	101.5	142	97.7	–
	2824	114.6	–	–	–
100,	No. 3824	103.2	No. 1493	99.9	–
	7562	105.1	–	–	–
	7563	102.8	–	–	–
	90357	101.6	–	–	–
150,	No. 13811	107.7	No. 8376	98.5	–
	90459	110.0	2098	93.8	–
	90460	106.2	–	–	–
	13555	100.4	–	–	–
	2096	108.6	–	–	–
200,	No. 90236	101.2	No. 13808	91.9	No. 237
	230	101.2	11048	99.1	–
	298	101.7	–	–	–
300,	–	–	No. 11686	85.8	–

Average registration of 81 meters at 43 per cent. load is 101.3 per cent.

PERCENTAGE REGISTRATION OF WRIGHT MAXIMUM DEMAND INDICATORS — *Continued.*

At 66 Per Cent. Load.

RATING OF INDICATORS (AMPERES).	Registering too Much.	Registration (Per Cent.).	Registering too Little.	Registration (Per Cent.).	Registering correctly.
5,	No. 90433	100.9	No. 12441	92.8	–
	14909	100.9	12885	97.3	–
	14545	104.8	11	97.9	–
	–	–	95049	95.8	–
	–	–	12613	97.9	–
10,	No. 93352	103.3	No. 9838	93.5	–
	96157	102.6	14285	98.8	–
	15071	101.5	15464	97.3	–
	8815	105.3	13718	98.5	–
	9431	103.4	93718	99.2	–
15,	No. 7208	103.5	No. 5603	99.5	No. 13819
	2757	104.7	5165	97.7	–
	–	–	6538	97.0	–
	–	–	15650	95.7	–
	–	–	11689	97.3	–
	–	–	5551	97.2	–
	–	–	2871	97.5	–
25,	No. 91286	101.8	No. 4785	92.0	No. 4362
	3729	101.6	473	99.4	–
	6992	100.6	9110	96.2	–
	6974	101.3	–	–	–
	2563	103.1	–	–	–
	2981	101.8	–	–	–
35,	No. 12448	114.9	No. 11880	99.4	–
	3978	103.7	10961	96.5	–
50,	No. 90764	102.1	No. 12030	98.4	–
	11858	104.3	–	–	–
	7661	111.9	–	–	–
	4431	111.1	–	–	–
	3961	100.6	–	–	–
	6440	102.3	–	–	–
	3484	105.6	–	–	–
	10580	102.1	–	–	–
	1431	100.6	–	–	–
75,	No. 10914	102.0	No. 4872	99.5	No. 3674
	3004	104.0	94459	95.0	–
	4582	100.5	142	95.5	–
	10984	102.0	–	–	–
	11342	105 0	–	–	–
	2824	114.4	–	–	–
100,	No. 7562	103.6	No. 1493	99.1	–
	7563	102.5	3824	99.8	–
	90357	105.5	–	–	–
150,	No. 13811	105.7	No. 2098	97.5	No. 2096
	8376	100.7	–	–	–
	90459	114.0	–	–	–
	90460	103.3	–	–	–
	13555	102.3	–	–	–
200,	No. 90236	102.7	No. 13808	99.6	–
	230	101.2	–	–	–
	237	101.9	–	–	–
	298	101.9	–	–	–
	11048	103.5	–	–	–
300,	–	–	No. 11686	91.0	–

Average registration of 81 meters at 66 per cent. load is 101.1 per cent.

PERCENTAGE REGISTRATION OF WRIGHT MAXIMUM DEMAND INDICATORS — *Concluded.*

At 90 Per Cent. Load.

RATING OF INDICATORS (AMPERES).	Registering too Much.	Registration (Per Cent.).	Registering too Little.	Registration (Per Cent.).	Registering correctly.
5,	No. 14409	101.1	No. 12441	92.3	No. 90493
	14545	104.8	12885	98.9	–
	–	–	11	98.9	–
	–	–	229	98.9	–
	–	–	12613	97.1	–
10,	No. 93352	101.3	No. 9838	91.3	–
	96157	100.6	14285	98.9	–
	15071	102.2	15464	98.9	–
	8815	110.0	13718	97.8	–
	9431	101.7	93718	96.9	–
15,	No. 2757	103.0	No. 5603	99.6	No. 7208
	–	–	5165	98.5	–
	–	–	6538	98.9	–
	–	–	15650	97.0	–
	–	–	11689	98.3	–
	–	–	5551	98.5	–
	–	–	13819	98.5	–
	–	–	2871	97.9	–
25,	No. 91286	102.8	No. 3729	99.3	–
	4362	100.9	6992	99.3	–
	2563	101.0	4785	93.0	–
	2981	100.8	6974	99.3	–
	–	–	473	96.7	–
	–	–	9110	95.2	–
35,	No. 12448	108.3	No. 11880	99.4	No. 10961
	3978	108.8	–	–	–
50,	No. 90764	102.2	No. 1431	98.9	–
	11858	105.0	12030	97.8	–
	7661	109.4	–	–	–
	4431	105.6	–	–	–
	3961	100.6	–	–	–
	6440	103.2	–	–	–
	3484	109.6	–	–	–
	10580	102.2	–	–	–
75,	No. 10914	100.7	No. 4872	99.6	–
	3004	102.6	94459	95.6	–
	3674	101.8	142	97.0	–
	4582	101.5	–	–	–
	10984	101.5	–	–	–
	11342	101.8	–	–	–
	2824	113.2	–	–	–
100,	No. 3824	100.6	–	–	No. 1493
	7562	106.9	–	–	–
	7563	100.6	–	–	–
	90357	111.+	–	–	–
150,	No. 13811	103.7	No. 2096	96.7	–
	8376	102.6	2098	96.3	–
	90459	114.8	–	–	–
	90460	102.2	–	–	–
	13555	110.4	–	–	–
200,	No. 90236	101.1	–	–	No. 13808
	230	102.2	–	–	–
	237	105.0	–	–	–
	298	101.8	–	–	–
	11048	103.3	–	–	–
300,	–	–	No. 11686	91.2	–

Average registration of 81 meters at 90 per cent. load is 101.1 per cent.

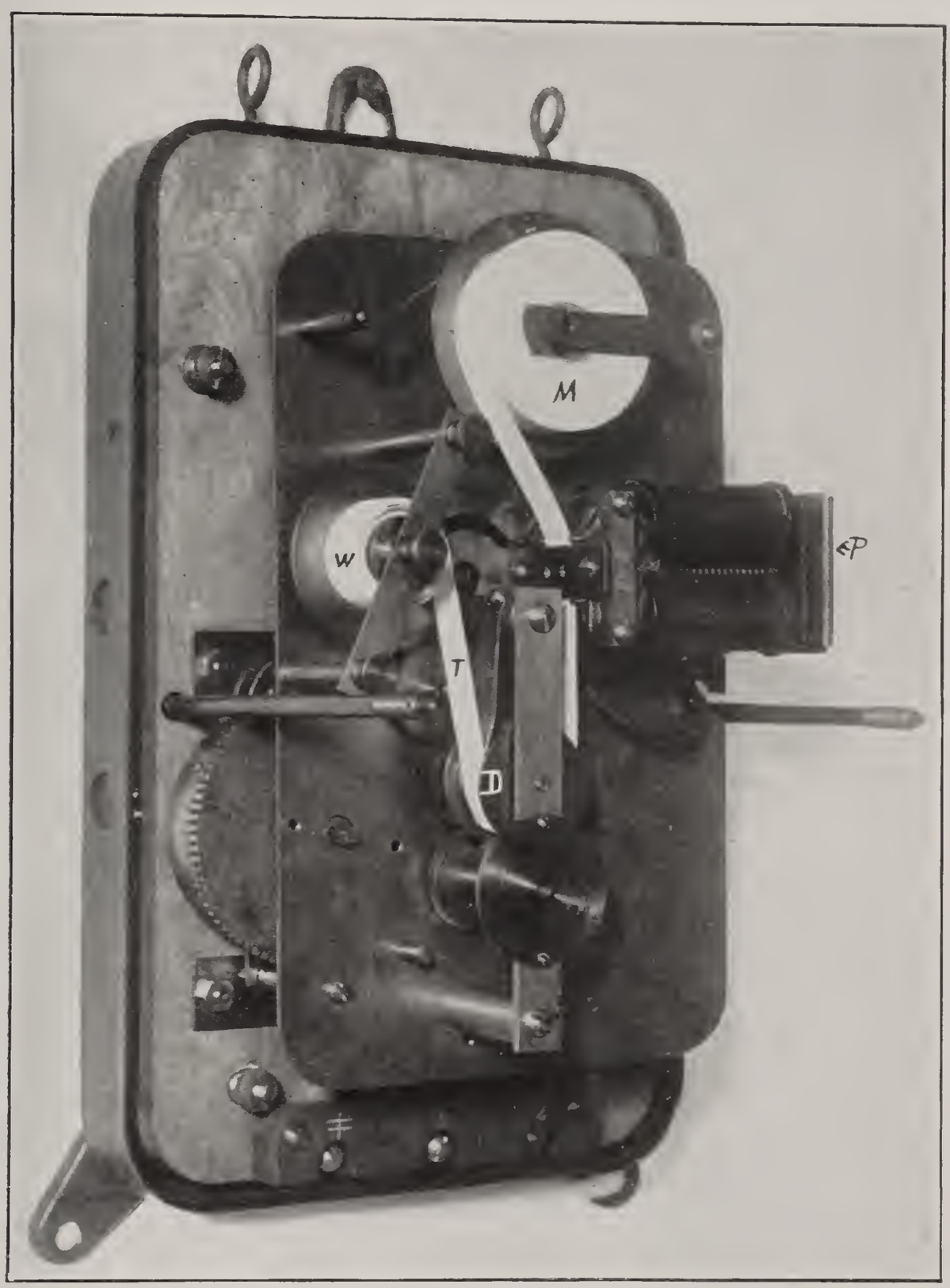
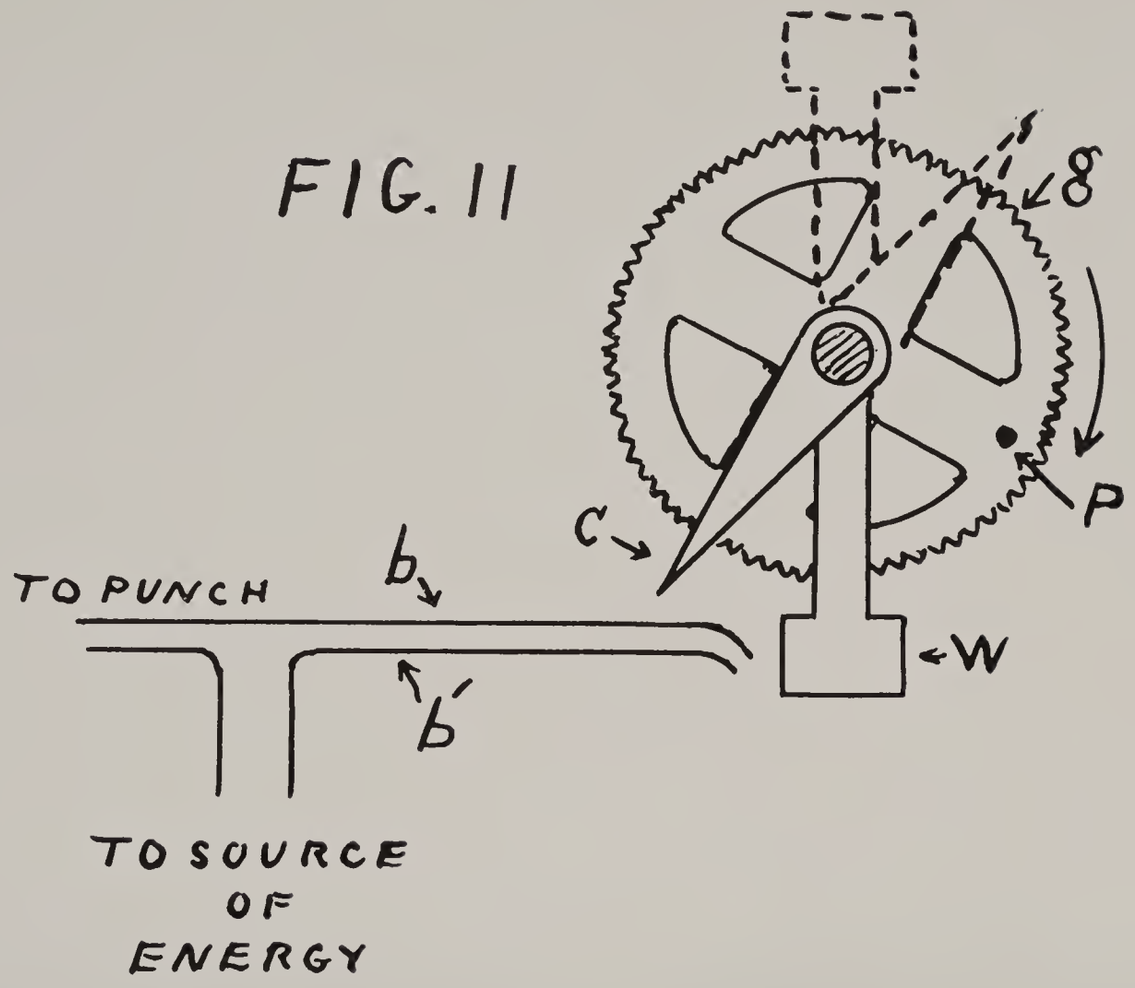


Fig. 10. — Ingalls Relay Demand Indicator.

FIG. 11



CONTACTOR FOR INGALLS RELAY DEMAND INDICATOR

The Ingalls Relay Demand Indicator.

This device may be regarded as an auxiliary to the watt-hour meter by means of which the number of revolutions made by that instrument in a given time (half an hour) may be obtained from a record impressed on a uniformly moving paper tape. From this record, knowing the disc constant of the watt-hour meter and the gear ratio of the contact arrangement which is described later, the demand may be calculated.

The Edison Company has 61 of these indicators installed for billing purposes (June 30, 1911).

Fig. 10 shows the general appearance of one of these devices adapted to obtain on a single tape the records from two watt-hour meters. A very powerful, double-spring clock is used to drive the drum (D) over which the paper tape (T) is passed; to prevent slipping of the tape the drum is armed with needle points. By the clockwork the tape is drawn from the magazine (M) and caused to pass in front of the punch (P). W is the take-up roll; it is actuated by a friction drive from the clock.

Whenever a current is passed through one of the magnets of the punch (P) the corresponding armature is drawn in and a perforation made. Once each hour, by the clock, a mark is printed on the tape.

To actuate the punch a contact arrangement is added to the counter of the watt-hour meter; this is shown diagrammatically in Fig. 11. The wheel (g) is driven by the counter and revolves once for each 100 revolutions of the meter disc. The contactor (C) and the weight (W) are in one piece, which is loose on the shaft. The pin (P) is long enough to engage with this piece and then push it to the dotted position, when it suddenly falls forward. This causes the contactor (C) to connect b and b′ (which are in reality in the same plane) for an instant, thus closing the circuit through the magnets of the punch, which then perforates the tape. After 100 revolutions of the meter disc this operation is repeated. The appearance of the record thus obtained is seen in Fig. 12.

The tapes are replaced once a week; when this is done the time of the beginning of the record is recorded on the tape, as is the time of the ending of the record.

To find the maximum demand the tapes are examined and those parts where the perforations appear to be closest together are selected for measurement, a scale of a length corresponding to the motion of the tape in half an hour at that point is applied to it, and the number

of whole spaces and fractions in this length is determined. Each one of the spaces corresponds to 100 revolutions. Thus the number of revolutions made by the watt-hour meter in half an hour is found. The ordinary formula for the watt-hour meter is

$$\text{Kilowatts} = \frac{N \times K \times 3600}{t \times 1000},$$

where N is the number of revolutions of the meter disc occurring in t seconds and K is the disc constant of the meter. The kilowatts demand corresponding to one space on the paper tape, that is, to 100 revolutions, if they occurred in one-half an hour would then be

$$\frac{100 \times K \times 3600}{30 \times 60 \times 1000} = 0.2\ K$$

If instead of one space in half an hour we have any other number, the above is simply multiplied by the number of spaces. To illustrate: take the tape shown in Fig. 12 and assume that the disc constant (K) of the watt-hour meter is 25. Then the kilowatts demand is given by

$$\text{K.W. demand} = .2 \times 25. \times (\text{number of spaces in half an hour}).$$

Where the perforations are closest together there are 8 spaces in half an hour, so the demand is

$$0.2 \times 25. \times 8.0 = 40\ \text{K.W.}$$

It will be noticed that the device gives information of value other than the maximum demand, for it tells just how the customer's load varies, and gives the hour at which the maximum demand is reached. This may or may not be at the time of the peak of the load on the station.

The accuracy of this device depends on two things: first, the accuracy of the watt-hour meter to which it is applied; second, on the rate of the clock mechanism. An examination of a number of tapes taken at random from the files of the Edison Company showed these extreme variations: one clock lost thirty-two minutes in one hundred and sixty-five hours, or on the average was in error by about 3-10 of 1 per cent. Another clock gained twenty-three minutes in one hundred and sixty-six hours, an average error of a little over 2-10 of 1 per cent. The error which is of importance is thus that due to the watt-hour meter.

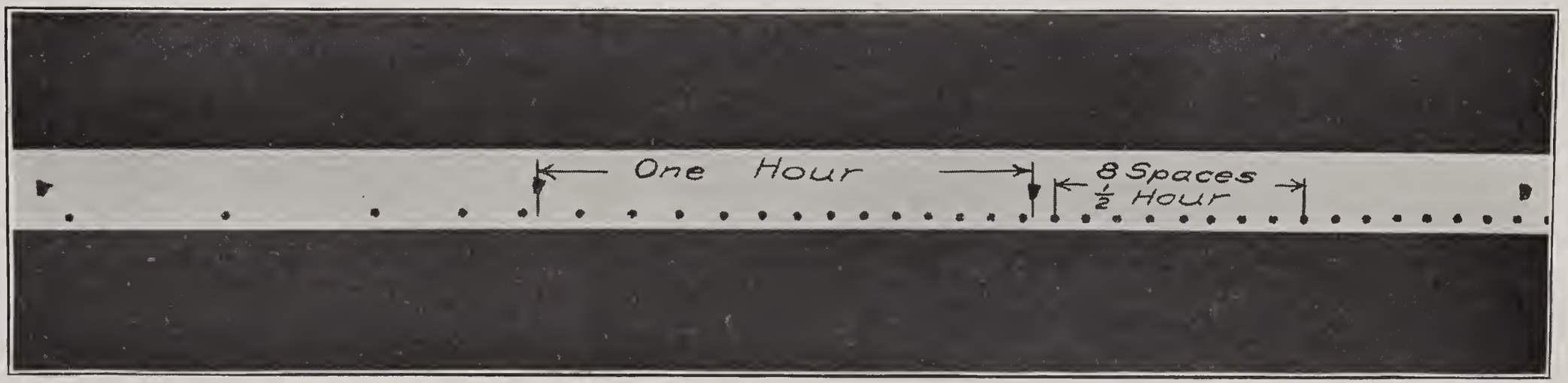


Fig. 12.

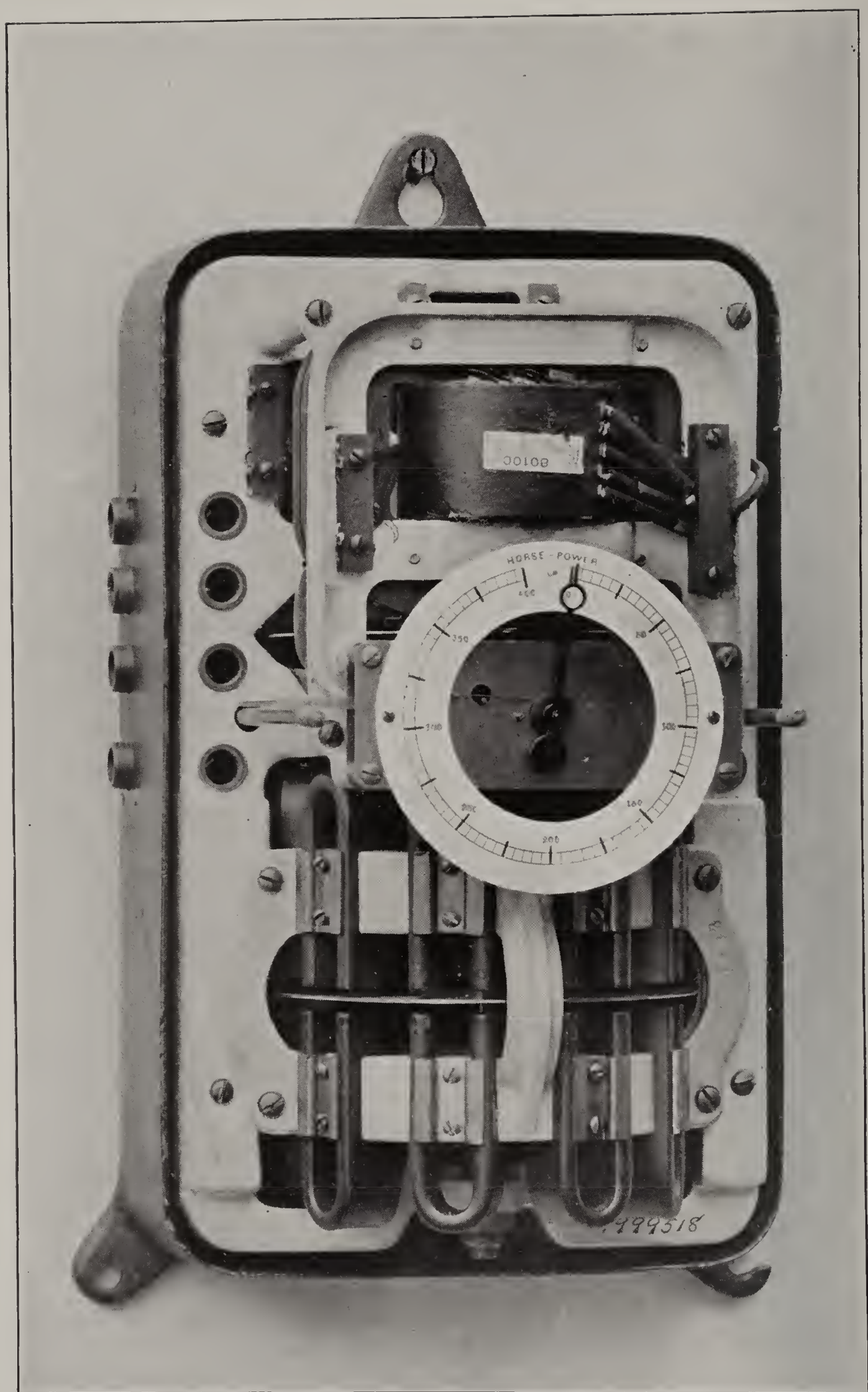


Fig. 13. —256430. Type W Polyphase Maximum Demand Indicator.

The General Electric Type W Watt Demand Indicator.

Although this instrument is in common use throughout the State, it is not employed by the Edison Electric Illuminating Company of Boston, and consequently was not included in the first part of this report.

This device is made for use on alternating current circuits and for polyphase work only; it is essentially a polyphase-indicating wattmeter of the induction type, which is provided with an exceedingly strong electromagnetic damping system, so that its response to variations of the load is rendered very slow. The indications are given on a dial which is provided with two pointers, one of which indicates the load (subject to the time-lag of the instrument); the other shows the sustained maximum to which the load has risen. Fig. 13 gives a general view of the instrument and Fig. 14 shows in diagram its essential features. W_1 and W_2 are the two wattmeter elements which are essential to the measurement of power in the ordinary polyphase systems, for, as is usual in such measurements, the "two wattmeter method" is here employed; D_1 is the disc in which currents are induced by the elements W_1 and W_2; these currents react with the magnetic fields set up by W_1 and W_2 and cause the indication of the instrument. The disc is made of brass in order that the effect of temperature changes may be minimized; this is because the electrical resistance of alloys like brass varies much less with changes of temperature than does that of pure metals, for instance, copper.

The controlling spring against which the movable system deflects is at S. In reality three springs are used in series; this is done in order that the movable system may be enabled to make 3 complete revolutions without complications arising from the spring being twisted too tightly.

The damping disc (D_2) is of copper and rotates between two sets of magnets (M and M'); each magnet is adjustable vertically so that the strengths of the magnetic fields through which the disc moves may be varied; in this manner the strengths of the currents induced in the disc when it turns, and consequently the retardation experienced by it, may be altered; by this means the rapidity with which the instrument responds to changes of load may be adjusted. It is intended that the magnets be so set that 90 per cent. of the registration is produced in five consecutive minutes.

The hand (H_1) is driven from the spindle by a system of gearing, and moves over a dial graduated in kilowatts; as it moves it pushes before it the hand (H_2), which is loose on the shaft and provided with

a ratchet (R) and a light spring (S′), which tends to turn the hand back against the ratchet; the result is that H_2 is pushed up to the maximum by H_1 and left there, when (owing to the decrease of the load) H_1 returns toward zero. The instrument may be set by opening the case and raising the ratchet, this allows S′ to return the pointer H_2 to zero, H_1 being previously turned back to that point. It will be seem that this device gives the power which is being used at any time, as well as the maximum demand in kilowatts; it gives no indication of the time when the maximum demand was called for.

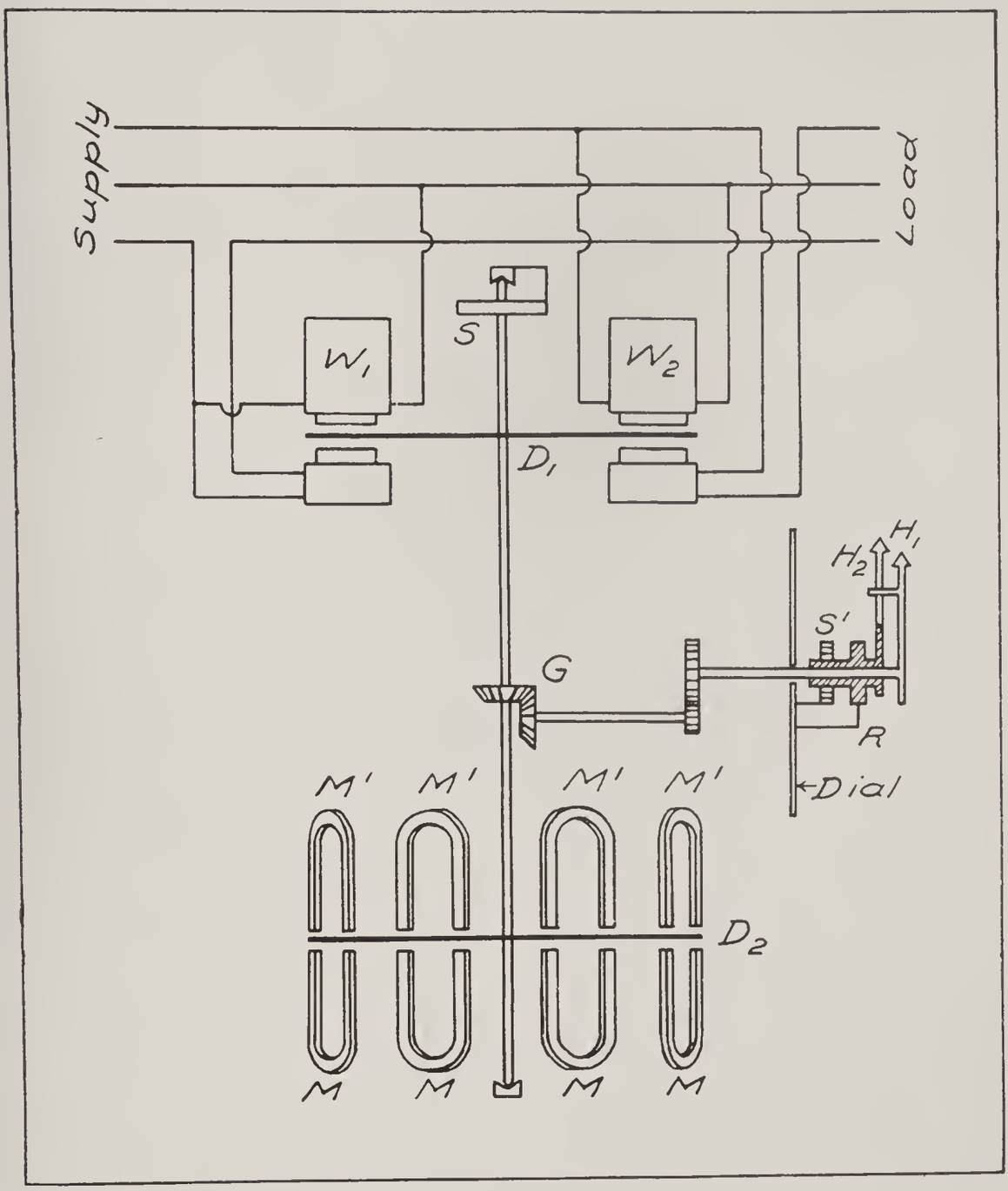


Fig. 14.

Appendix B.

THE EDISON ELECTRIC ILLUMINATING COMPANY OF BOSTON.

SCHEDULE OF RATES — COMMERCIAL.

The following prices for electricity are in force, commencing June 1, 1910: —

Schedule A, Lighting Rates. — Applies to all lighting customers who do not make yearly agreements, embodying certain guarantees.

Schedule B, Power Rates. — Applies to all power customers.

Schedule C, Yearly Lighting Rates. — Applies to all lighting customers who make yearly agreements, embodying certain guarantees.

Schedules D and D–1, Permanent Electric Rates. — Apply to all customers who make long-term agreements, embodying certain guarantees.

SCHEDULE — A.

Lighting Rates — Commercial.

Electricity for any use will be sold, under this schedule, to any customer who has signed an agreement for electric service, embodying the terms and conditions of the company.

A price of 11 cents per kilowatt hour will be charged for all electricity furnished under this schedule, and the minimum charge will be $1 per month per meter.

SCHEDULE — B.

Power Rates — Commercial.

Electricity for power use will be sold, under the following schedule, to any customer who has signed an agreement for electric service, embodying the terms and conditions of the company. "Power" is defined as general motor service, cooking, heating, electroplating, charging storage batteries, and similar service, but does not include the running of dynamos for electric lighting purposes.

A price of 12 cents per kilowatt hour will be charged for all electricity furnished under this schedule, with the following deductions, and the minimum charge will be $1 per month per meter: —

First Deduction. — A price of 9 cents per kilowatt hour will be charged for all electricity furnished in excess of 23 and not exceeding 103 hours' use of the demand[1] for each month.

Second Deduction. — A price of 6 cents per kilowatt hour will be charged for all electricity furnished in excess of 103 hours' use of the demand for each month.

Third Deduction. — Whenever that portion of a customer's bill which is calculated at the 9 cent and 6 cent rate, or both, exceeds $10 per month, a discount of 70 per cent. will be allowed on such excess over $10.

Fourth Deduction. — Whenever a customer's bill, after the foregoing deductions have been made, exceeds $100 per month, a discount of 30 per cent. will be allowed on all in excess of $100.

Fifth Deduction. — Whenever a customer's bill, after the foregoing deductions have been made, exceeds an average rate of 11 cents per kilowatt hour, a deduction will be made to make the average rate 11 cents per kilowatt hour, but in no case less than $1 per month.

SCHEDULE — C.

Yearly Lighting Rates — Commercial.

Electricity for any use will be sold, under the following schedule, to any customer who has signed an agreement for yearly electric service, embodying the terms and conditions of the company.

Fixed Costs.

A price of $60 per year, payable in equal monthly instalments, will be charged per kilowatt of the demand[2] up to and including 15 kilowatts.

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[1] The demand is the greatest amount of electricity used by the customer at any one time. Until such time as the company installs one or more indicators, automatically to determine the demand, either in whole or in part, it may estimate the demand. The demand on any circuit, when an indicator is installed, will be the average of the regular monthly readings of the indicator, between October 1 and the following February 1 in each year. The demand so determined, beginning February 1 of each year, shall be the demand for the next twelve months, except that the demand in no case shall be less than ⅓ of the highest reading during the previous twelve months, and in no case shall be less than 1 kilowatt; and provided that if any direct-connected elevator (as defined below) be installed the demand shall not be taken at less than 10 kilowatts. A direct-connected elevator is defined as being an elevator run in guides and in which the car starts at the same time as the motor. The customer has the privilege of having the indicator cut out one night in each month, proviced a 48-hour written notice is given to the company.

[2] The demand is the greatest amount of electricity used by the customer at any one time. Until such time as the company installs one or more indicators, automatically to determine the demand, either in whole or in part, it may estimate the demand, but in no case shall it be taken at less than ²⁄₁₀ of a kilowatt. The demand on any circuit, when an indicator is installed, will be the greatest reading of the indicator between November 1 and the following February 1 of each year, and the demand so determined, beginning February 1 of each year, shall be the demand called for by the agreement for the next twelve months, except that the demand in no case shall be less than ⅓ of the highest reading during the previous twelve months. The customer has the privilege of having the indicator cut out one night in each month, provided a 48-hour written notice is given to the company.

First Deduction. — A price of $36 per year, payable in equal monthly instalments, will be charged per kilowatt of the demand for all kilowatts exceeding 15 and up to and including 55.

Second Deduction. — A price of $30 per year, payable in equal monthly instalments, will be charged per kilowatt of the demand for all kilowatts exceeding 55.

These prices do not include the supply of electricity.

Running Costs.

A price of 5 cents per kilowatt hour will be charged for all electricity furnished under this agreement up to and including 1500 kilowatt hours per month.

First Deduction. — A price of 3 cents per kilowatt hour will be charged for all electricity furnished under this agreement exceeding 1500 kilowatt hours and up to and including 5500 kilowatt hours per month.

Second Deduction. — A price of $2\frac{1}{2}$ cents per kilowatt hour will be charged for all electricity furnished under this agreement exceeding 5500 kilowatt hours per month.

SCHEDULE — D.

Permanent Electric Rates.

Electricity for any use in specified premises will be sold, under the following schedule, to any customer who has signed an agreement for at least 50 kilowatts of permanent electric service, embodying the terms and conditions of the company.

Fixed Costs.

A price of $60 per year, payable in equal monthly instalments, will be charged per kilowatt of service up to and including 15 kilowatts.

First Deduction. — A price of $36 per year, payable in equal monthly instalments, will be charged per kilowatt of service for all kilowatts exceeding 15 and up to and including 55.

Second Deduction. — A price of $30 per year, payable in equal monthly instalments, will be charged per kilowatt of service for all kilowatts exceeding 55.

Third Deduction. — A price of $15 per year, payable in equal monthly instalments, will be charged per kilowatt of service for all kilowatts exceeding 155, provided that the customer has applied for high tension transmission line service.

These prices do not include the supply of electricity.

Running Costs.

A price of 5 cents per kilowatt hour will be charged for all electricity furnished under this agreement up to and including 1500 kilowatt hours per month.

First Deduction. — A price of 3 cents per kilowatt hour will be charged for all electricity furnished under this agreement exceeding 1500 kilowatt hours and up to and including 5500 kilowatt hours per month.

Second Deduction. — A price of $1\frac{1}{2}$ cents per kilowatt hour will be charged for all electricity furnished under this agreement exceeding 5500 kilowatt hours and up to and including 105,500 kilowatt hours per month.

Third Deduction. — A price of $1\frac{1}{4}$ cents per kilowatt hour will be charged for all electricity furnished under this agreement exceeding 105,500 kilowatt hours per month.

The above prices include lamps and care.

Optional Deduction. — If lamps and care are not supplied by the company, it will deduct from the net amount of the bill, as otherwise rendered, $\frac{1}{2}$ cent per kilowatt hour.

Excess Costs.

The company will provide capacity for intermittent overloads up to 40 per cent. in excess of the kilowatts applied for by the customer.

An excess price of 20 cents per kilowatt hour will be charged for all electricity furnished at any time in excess of the kilowatts applied for by the customer.

SCHEDULE — D–1.

Permanent Electric Rates (Theatrical).

Electricity for any use in specified premises will be sold under the following schedule to any customer who has signed an agreement for not over 150 kilowatts of permanent theatrical electric service, embodying the terms and conditions of the company.

Fixed Costs.

A price of $2,160 per year, payable in equal monthly instalments or in such instalments in advance as are convenient to the customer, will be charged.

This price does not include the supply of electricity.

Running Costs.

A price of 3 cents per kilowatt hour will be charged for all electricity furnished under this agreement.

The above prices include lamps and care.

Optional Deduction. — If lamps and care are not supplied by the company, it will deduct from the net amount of the bill, as otherwise rendered, $\frac{1}{2}$ cent per kilowatt hour.

Excess Costs.

An excess price of 20 cents per kilowatt hour will be charged for all electricity furnished at any time in excess of 150 kilowatts.